POWER PLANT ENGINEERING

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Successful Pulverized Coal Installation

MILWAUKEE ELECTRIC RAILWAY & LIGHT CO. SHOWS EXCELLENT RESULTS AFTER 2 YR. OPERATION AND SEVERAL CHANGES IN FURNACE DESIGN; PLAN NEW PLANT. BY I. L. KENTISH-RANKIN.

THE LARGEST INSTALLATION of pulverized coal burning equipment under steam-raising boilers in the world is that of the Milwaukee Electric Railway & Light Co., at Milwaukee, Wis. This installation, in the Oneida Street station of the company, was planned early in 1918. By May of that year, one boiler and pulverized-coal apparatus was installed and until August of the same year was operated under various experimental conditions. Since that time, many changes have been made and lessons taught by experience acted upon. Today there are five 468-hp. boilers, each being fired by pulverized coal. These units have proved so satisfactory after months of continuous operation under operating conditions that the Milwaukee Electric Railway & Light Co. has already commenced the construction of another plant that will utilize pulverized fuel exclusively.

The Oneida Street station is an old station, and the present installation of pulverized coal equipment was necessarily a compromise because of space restrictions and the fact that the new equipment had necessarily to be located as conditions permitted. Under these circumstances the present layout of coal-handling apparatus should not be looked upon as ideal, although it may perhaps be the best even under other conditions; experience alone will decide this point. Meanwhile the success of pulverized fuel at Oneida Street has been proved,

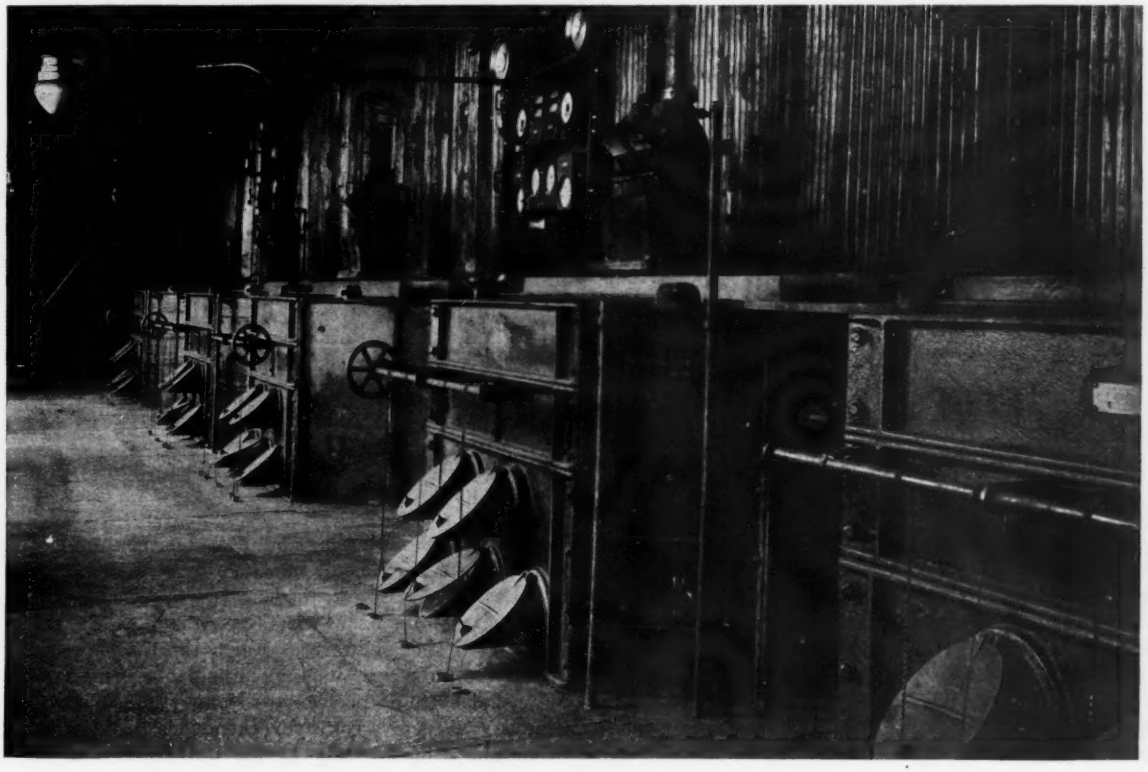


FIG. 1. BOILER ROOM AISLE, SHOWING FURNACES, AUXILIARY AND FURNACE INLETS AND INSTRUMENT BOARD

notwithstanding certain inconveniences for reasons advanced above.

Station Layout and Coal Movement

Between a station burning lump coal and one burning powdered coal, the chief differences are that with the powdered coal there is a large amount of coal treating to be done as compared with lump coal; and at the same time there is infinitely less ash to be handled. This fact is well brought out by the isometric view of Oneida Street station, Fig. 2, which shows the relative location of the various pieces of apparatus, the path followed by the fuel from the time it is dumped from the boats until the time it passes up the stack as gas or into the ash conveyor as slag.

The Milwaukee Electric Railway & Light Co. receives most of its coal by water. The coal is unloaded by grab bucket and dumped into the raw coal hoppers. From the raw coal hoppers the coal is passed through a magnetic separator which takes out pick-heads, bolts and nuts and similar objects and passes the coal over a scale to the coal crusher. From the coal crusher the coal is carried to the green coal bins by bucket elevator, of which there are five for each furnace. This arrangement permits each boiler and furnace to be treated as a separate unit in times of emergency or for test. Each of these bins has large storage capacity for coal, because crushed raw coal may be stored readily, whereas pulverized coal cannot be stored for any length of time in any considerable quantity, due to the rapidity with which it heats on the one hand and absorbs moisture on the other.

The coal passes from the green coal storage bins to the disintegrator along a horizontal conveyor, where it is transferred to a vertical conveyor. In the disintegrator the coal is broken up so that all will pass through ½-in. mesh and then passes to the drier. The drier measures about 65 ft. in length and 6 ft. in diameter, and consists of a cylinder which revolves and through the center of which passes a flue. The flue is open at its lower end, to permit the hot gases to escape and pass back in the chamber containing the coal and carry with them the moisture in the form of steam picked up from the coal. The drier is heated by a coal-burning furnace located adjacent to it. A cyclone separator and fan are employed for exhausting the moisture and drier gases, the fan being operated through countershafts from the drier, Fig. 3. Passing slowly through the drier as it revolves the coal gravitates to the lower end of the drier, to be conveyed by a propeller or screw conveyor to a vertical bucket conveyor, which carries it up to the dried coal bin. By this time the coal is quite small, all passing through a ½-in. mesh, and dry, not containing more than 1 to 2 per cent of moisture.

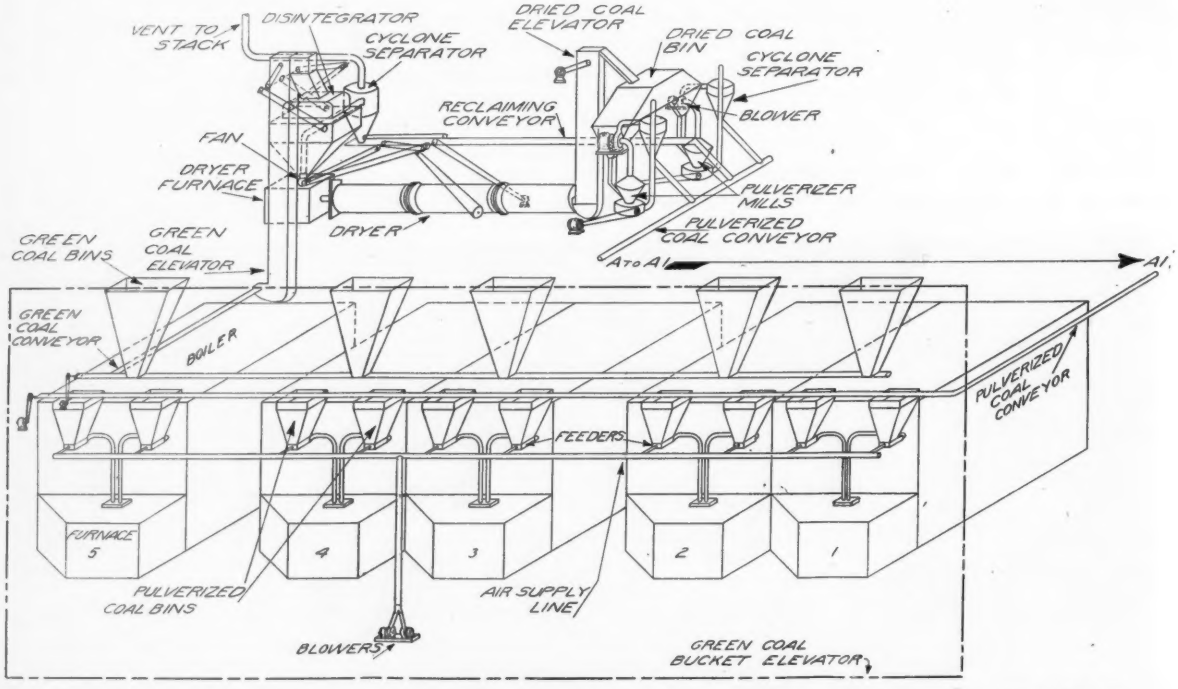


FIG. 2. ISOMETRIC LAYOUT OF PULVERIZED COAL PLANT, SHOWING LOCATION OF EQUIPMENT AND PATH OF TRAVEL FOLLOWED BY FUEL

Passing downward, the coal now is fed into the 5-ball pulverizer mill, of which there are two. Only one is used at a time, however. When the coal has emerged from the pulverizer it is an impalpable powder of such size that 80 to 85 per cent will pass through a 200-mesh screen. A screw conveyor then carries the powdered coal along horizontally to the pulverized coal storage bins. There are two of these for each furnace, an arrangement that permits of either bin becoming clogged or taken out of service without interfering with the performance of the furnace. Beneath the bins a steel gallery, suspended by angle-irons, is located to make inspection safe and simple. The coal is now prepared, and the remaining processes have to do with the utilization of the powdered coal as contrasted with the preparation

of the raw coal ready for utilization. Table I gives the data on the method of driving and size and type of motor employed in the preparation of the coal, and Figs. 2 and 4 show the location of the different pieces of equipment.

Burning the Powdered Coal

From the pulverized coal bins the coal falls by gravity upon a motor-driven screw conveyor carried by the storage bin, Fig. 5, and is carried toward the burner. Adjacent to the conveyor, air from a mechanical blower is piped to the powdered coal feed line, Fig. 4. This air, forced draft, picks up the coal and carries it at high velocity along the burner feed line, through the air mixing chamber where additional air is taken in through vents, to the burner. The air used for injecting the coal, also used for combustion, is furnished by a motor-driven blower set serving all five units. There are actually two of these blower sets, but one is held in reserve, Fig. 6. The air entering at the air-mixing chamber immediately above the furnace, as shown in Fig. 1, is taken into the mixing chamber because of the low pressure in the furnace, and the amount thus drawn in can be controlled by dampers. Additional air is taken into the furnace through air vents in the furnace sides, as will be discussed later. In Table II is given the energy consumption, approximately, expended for the purpose of preparing and moving the pulverized coal and supplying air for both moving the coal and for combustion.

The Furnace Chamber

The exterior view of the furnace is shown in Fig. 1, while Fig. 4 gives a good idea of the size and shape of the furnace chamber. The large furnace space calls for special comment, as does the location of the burner, which results in the flame of burning coal passing down almost vertically. The actual combustion space is 1678

TABLE I. APPARATUS AND MOTOR SIZES FOR COAL HANDLING AND PREPARING

Coal crusher	1	20 hp. a-c., squirrel cage
Coal bucket conveyor	1	Driven by countershafts by
Magnetic separator	1	above motor
Green coal conveyor	1	10 hp. d-c., constant speed
Drier, moisture exhauster, dust collector and cyclone separator	1	30 hp. d-c., variable speed
Dry coal elevator	1	5 hp. d-c., constant speed
Pulverizer	2	75 hp. each, d-c., constant speed
Pulverized coal screw conveyor	1	5 hp. d-c., constant speed
Forced draft blower	2	15 hp. each, d-c., variable speed
Suction fans, one per mill	2	40 hp. each, a-c., squirrel cage
Pulverized coal feeders (two per furnace)	10	1½ hp. d-c., variable speed

cu. ft., and the distance from the bottom row of tubes to the bottom of the furnace chamber is 15 ft. Placing the burners as shown, so that the coal is fed vertically down into the furnace, improves combustion by securing better mixing of air and coal, and at the same time lessens the likelihood of damage to the furnace brickwork under the influence of erosion, and intense concentrated heat, because the flame does not impinge directly upon any portion of the brickwork.

As already pointed out, the pulverized coal installation was made in a station already built, and many things had to be compromised. One was that the coal and slag conveyor could not be moved. The only alternative was to brick it in and build the furnace over it (Fig. 4). This is the only part of the furnace that has given any sign of trouble and here occasional relining is necessary. It should be specifically pointed out, however, that this condition is not strictly chargeable to the use of pulverized fuel, but to the fact that the coal and ash conveyor could not be moved. With the foregoing exception, no furnace troubles have developed since the present furnace design was adopted. It was necessary, however, to build and redesign the furnace five times before the present-day success was attained.

That the present furnace is successful is proved by the fact that it is possible to operate at 180 per cent of boiler rating for several days at a time without a stop, maintaining about 13 per cent of CO_2, without any sign of brick troubles. Incidentally, this fact emphasizes the absence of clinker troubles and loss due to cleaning fires. It is the opinion that the vertical flame is largely responsible for the absence of refractory troubles, absence of tube troubles and the good combustion efficiency maintained at all times, namely 13 per cent

TABLE II. APPROXIMATE POWER CONSUMPTION PER TON IN PREPARING AND BURNING POWDERED COAL

Application	Kw-hr. Consumed per Ton
Conveyors, crusher, elevators, drier, forced-draft blower and feeders	5.73
Pulverizer	16.72
Total kw-hr.	22.45
Coal equivalent, at 1.5 lb. coal per kw-hr., lb.	33.68
Coal consumed by drier furnace, lb.	25.66
Total coal and equivalent, lb.	59.34

Note - These figures are taken from the report of the test, and must be considered as approximate only for average daily operation.

CO_2 and better. As a matter of fact, it has been found that 13 per cent of CO_2 gives the most satisfactory temperature on the basis of high combustion efficiency on the one hand and long refractory life on the other. The large combustion space is another factor, of course, the volume being about five times that usually encountered with stoker firing. In this connection, it may be stated that such a large furnace volume has been obtained quite inexpensively, since the furnace chamber has been built downward instead of upward. Station restrictions necessitated this, but it is a money-saving feature.

Referring once again to Fig. 1, attention is drawn to the air inlets seen in the furnace walls. There are five of these openings above the floor and seven below the floor. These auxiliary air inlets, in addition to the forced draft and the air taken in at the air-mixing chamber immediately above the furnace, shown also in Fig. 1, deserve special consideration. These 12 air inlets are rarely touched, once they have been properly adjusted. They serve a two-fold purpose: they furnish air, by induced draft due to the vacuum in the furnace chamber, for complete combustion, but more important still, they allow comparatively cool air to enter the furnace where such air can do most good in the way of cooling the brickwork of the furnace. This is especially true of the seven vents below the floor, which allow air to pass where it can be most effective.

Three sources of air supply are available for adjustment and control, namely the forced draft at the feed line, the air inlets at the air-mixing chamber and the air inlets in the furnace walls. It is usual, however,

to do practically all the regulating with the breeching damper, since the auxiliary air—the air that does not serve to help carry the powdered fuel as well as accomplish combustion—depends upon the low pressure in the furnace chamber. In Fig. 1, besides the boiler instruments panel can be seen the controls for the breeching dampers and also those for the furnace air inlets. Both can be operated at the same time by one man while he watches his draft gages on the instrument board.

Boiler-Room Instruments

An instrument board installed in the passageway between each pair of boilers serves to carry the instruments for the boiler on either side of it. Each boiler is equipped with a steam-flow meter, a recording draft gage for registering the draft over the fire (in furnace chamber) and in the last pass; a draft gage of the indicating type for showing the same as above; a recording thermometer for metering the temperature of the steam and the temperature of the stack gases; and a draft gage for the purpose of checking instantly the working of any of the other draft gages.

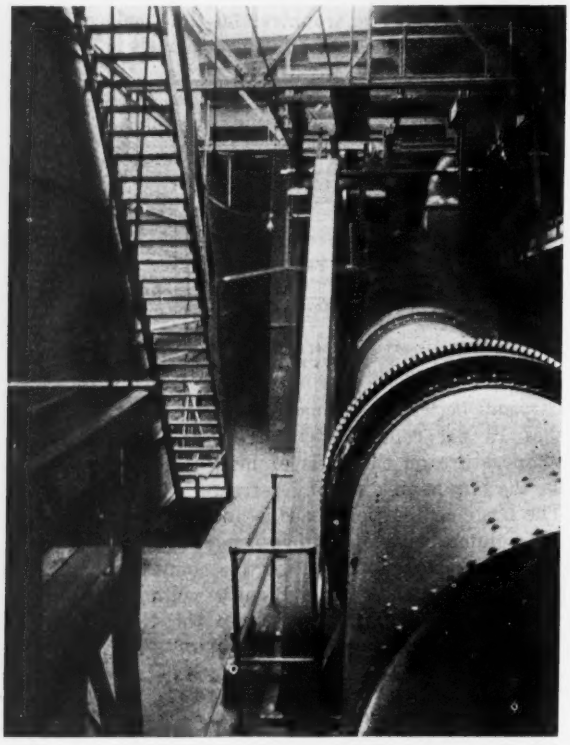


FIG. 3. COAL DRIER, EXHAUSTER DRIVEN BY COUNTERSHAFT

A CO_2 recorder is located in the boiler-room aisle for recording the carbon dioxide of any furnace. The gases are picked up in the third pass, directly below the damper. This instrument may be changed from any furnace to any of the others, a practice that is usually done about every two or three hours. A smoke recorder is also connected to the one stack that serves the five powdered coal furnaces as well as several stoker-fired furnaces in a different section of the station. All coal is weighed and a daily and weekly record kept of pounds of coal per kilowatt-hour generated. Water is not measured.

Some Operating Experiences With Pulverized Coal

Daily operation with pulverized coal burning under first one and eventually five boilers, meeting the daily variations of load as called for by routine plant performance, has caused to be developed a number of interesting practices and precautionary measures. These serve to give a better insight into pulverized coal combustion and what its use implies.

Moisture has proved itself one of the difficulties to be guarded against. Moisture in the powdered coal interferes with coal movement, jeopardizes the mixing of air and fuel, and may even shut down a furnace altogether by clogging up the feed lines. Combustion is, of course, made difficult as well as erratic. Difficulties due to moisture have, however, been practically eliminated by reducing the moisture content in the coal received from the drier to from 1 to 2 per cent, and by taking care that no moisture is able to enter the feed lines, dry coal and pulverized coal storage bins. Another precaution now observed is to keep the upper zones of the station dry so that moisture is not drawn in from the outside. Another trouble that developed at first, but which has since been eliminated, was on account of coal leakage from the coal feed lines into the station through leaks and cracks and other openings. The loss of coal in this way resulted in ankle-deep dust, discomfort, and a loss of coal that not only showed up in the fuel bill but increased the cost of preparation. Dust-proof joints, the sealing up of openings and care in making joints solved this difficulty. Today the boiler room is clean and dust free.

Banked fires are not feasible with pulverized coal; nor are they necessary. Any burner may be turned off and as readily turned on, provided the furnace temperature is sufficient to ignite the coal. At Oneida Street it is the custom to shut down a furnace by turning off the coal supply, and employ the stored heat in the brickwork to keep up the steam pressure and take care of the radiation losses and loss of heat through condensation in the boiler header. In this way, by manipulating the stack or breeching damper, a boiler may be "banked" for several hours, and yet be ready for immediate steaming on turning on the burner. The whole process of getting a furnace and boiler back occupies only a few seconds.

One of the facts soon emphasized was the importance of synchronizing and maintaining the supply of air with the coal. If the air supply, ordinarily obtained by forced draft taken into the burner feed line just below the pulverized coal bin, stops and the coal feed is not stopped also, the feed line soon becomes clogged in a way that is quite difficult to clear, because the powdered coal packs tightly under the compressing influence of the motor-driven screw conveyor. This condition has been eliminated by connecting the motor control of the pulverized coal feed motors with the motor control of the forced-draft blower motors. If the latter shut down, they shut down the motor-driven pulverized coal feed screw conveyors also. Another very interesting feature of the forced draft air supply is that steam jets are installed to take the place of the motor-driven blowers on a moment's notice. If it becomes necessary to shut down the blower sets, all that requires to be done is

to turn on the steam jets and operate in this manner, without any serious loss of time or capacity, for several hours if need be. Each burner has its complement of steam jets.

The percentage of CO_2 maintained is less than a question of what is possible and rather the highest percentage that is economical. It has been found that if 13 per cent CO_2 is maintained the furnace refractories stand up without trouble and slag difficulties do not occur. At higher temperatures, slag troubles begin to occur. As a matter of fact, excess air is purposely allowed to enter through the air vents in the furnace walls to prevent slagging.

Pulverized coal in storage tends to heat rapidly, spontaneous combustion then occurring. Moreover, pulverized coal also absorbs moisture extremely readily. At Oneida Street, the pulverized coal bins (two to each furnace) have been chosen of such size that the supply of prepared coal suffices and yet can be used at proper boiler rating without undue heating. The absence of storage limitations imposed by the dried coal and the green coal permit these coal bins to be of larger storage capacity. The storage capacity of the green coal hoppers are such that ample coal may be stored in each, to be fed to the drier as needed. By this means, coal reserves may be kept on hand in the station, and the coal crusher may be shut down for long periods at a time. The motor-driven, pulverized coal screw conveyors and the forced-draft blowers are thus the only apparatus that must operate continuously, unless the steam jets replace the latter, if the plant is to keep on consuming fuel.

It is to John Anderson, chief engineer of power plants, and the Milwaukee Electric Railway & Light Co. that we are indebted for the privilege of visiting the plant, for obtaining the frank statements as to operation and permission to publish them. The data obtained during a 5-day test of the entire boiler room, as presented by Mr. Anderson, before the meeting in Milwaukee of the Employes' Mutual Benefit Association Technical League, is given in the following paragraphs.

Object of running these tests was to obtain complete data on the pulverized fuel installation for the purpose of making comparison with stoker installation, no attempt being made to establish boiler room conditions other than those maintained during regular operation.

To insure against any breakdowns during the test, the physical condition of the plant was carefully checked over, repairs being made wherever considered necessary. Boiler settings were examined and made air tight and all heat radiating surfaces were properly insulated.

All necessary precautions against water leakage, from or to the boiler, were taken. Blowoff lines were disconnected and blanked. Water column connections were broken and all regular feed lines to the boilers were disconnected and blanked.

All instruments were carefully calibrated and set, and arrangements for frequent checks were made wherever possible.

Preliminary tests were made on the various parts of the system so as to insure proper operating conditions during the final test. A twenty-four hour preliminary test was conducted on the entire plant for the purpose of training the personnel as well as that of trying out the test equipment.

Records

All data was recorded on prepared forms. Instrument readings were taken at regular intervals, varying from 15 min. periods on some instruments to one hour periods on others. Wherever possible automatic counters were used to check tallies made by operators. In other instances a double tally was made, each independent of the other.

Data was so arranged that approximate checks could be made after the burning of each forty and one-half tons of coal.

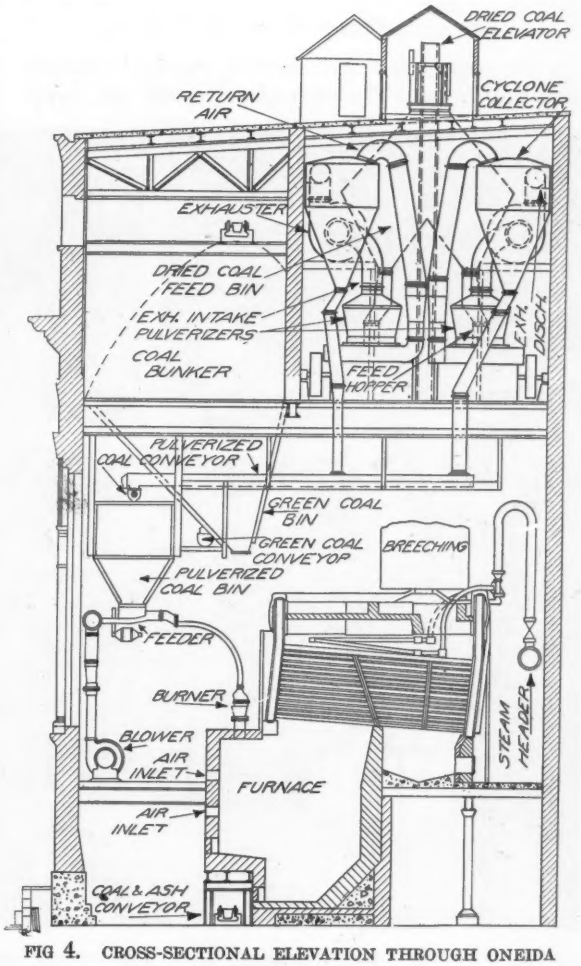


FIG 4. CROSS-SECTIONAL ELEVATION THROUGH ONEIDA STREET STATION

Hourly checks were made on the water in order to maintain a uniform rating.

Coal

With the exception of the first day, when 100 per cent Youghiogheny was used, the coal for the test was a mixture 50 per cent each Eastern Kentucky and Youghiogheny screenings, running approximately 25 per cent nut, 45 per cent pea, and 30 per cent slack. This coal is the same as is used in daily operation. The coal as supplied to the dryer after passing through disintegrator was approximately 50 per cent slack and 50 per cent small pea and nut, not any of the pieces being larger than one-half an inch.

During the progress of the test the coal was regularly

sampled at five points along the line of fuel travel. Samples taken at the coal scale were for moisture, proximate and ultimate analyses, while those taken at the dryer inlet and outlet, and burner outlets were for moisture determinations only. All samples were taken and made up according to the A. S. M. E. standards.

All determinations and analyses were made at the laboratories of the T. M. E. R. & L. Co., according to approved practices of the Bureau of Mines. An Emerson Bomb was used for obtaining calorific values of the coal.

Starting, Checking and Stopping

In pulverized fuel test practice, standard methods cannot be followed. The levels of pulverized fuel in the storage bins are the determining factor in starting, checking and stopping.

Previous to the starting signal for the final test, the green coal system was run clean of fuel and the pulverized fuel system filled to capacity. The conditions of the respective systems were identical for each check (after the burning of forty and one-half tons of coal) and at the close of the test. The amount of coal to be burned between checks was determined by the capacity of the green coal storage bunkers. Three bunkers of forty and one-half tons capacity each were available during the test, all of which were filled once in twenty-four hours.

Operating Conditions

Operation in the pulverizing room was changed somewhat during the test in order to fulfill conditions required in making the periodic checks of boiler operation. It was essential that the levels of the fuel in the pulverized bins should be controllable at certain hours of the day (at the time of check) and therefore operation of pulverizer equipment was extended over twenty-four hours, although, without these considerations, sufficient coal could have been pulverized during the eighteen hour run. As a result, irregular operation of the equipment—frequent starts and short runs—increased power consumption and decreased hourly capacities.

No interruptions, due to failure of equipment, occurred during the test. The pulverized fuel conveyor choked up on two occasions when the storage bins were allowed to overfill at a check hour.

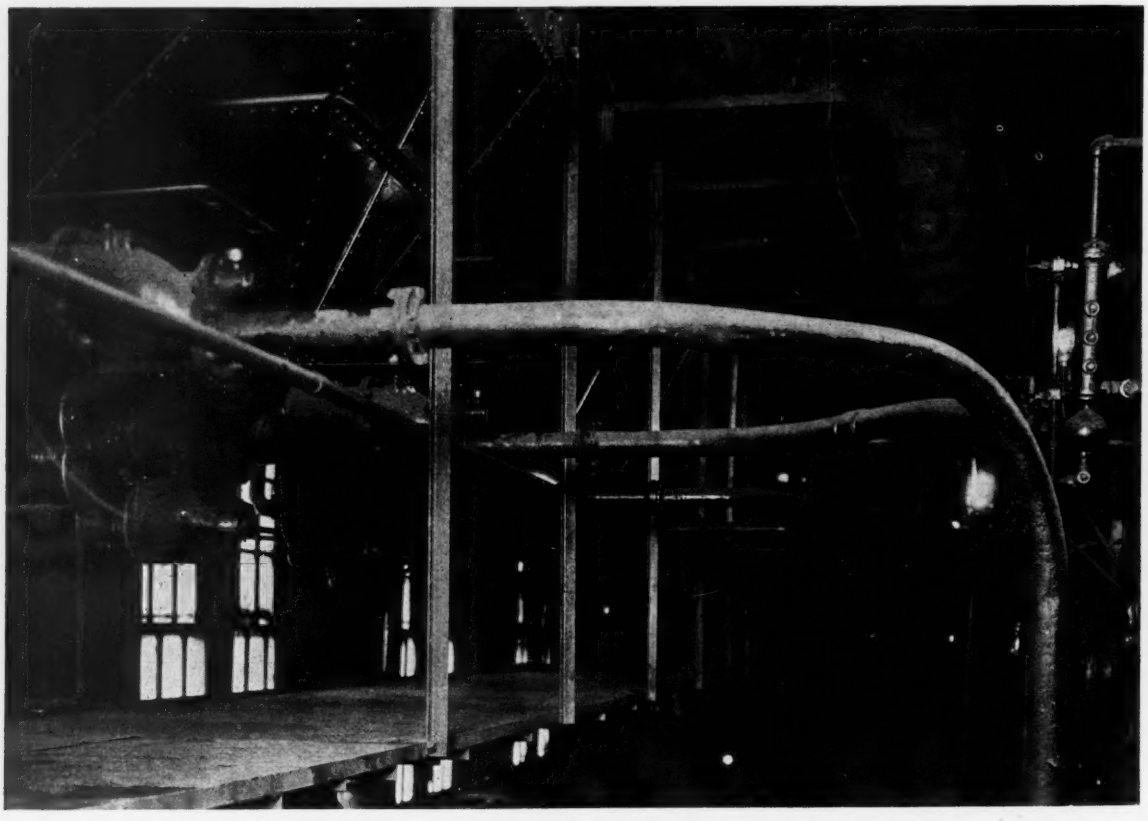


FIG. 5. VIEW OF PULVERIZED COAL BINS, MOTOR-DRIVEN FEEDERS AND SUSPENDED INSPECTION GALLERY

Uniform and satisfactory removal of moisture was affected by the dryer without any unusual regulation.

The firing of the furnace was varied, as it is ordinarily depending upon the moisture content of the green coal.

The pulverizers operated uninterruptedly and provided fuel of the desired fineness with little variation.

During the first twenty-four hours of the test, it appeared that moisture, with its attendant difficulties, was collecting in the storage bins. Cold air draughts through windows along side of the bins, caused this condition by rapidly condensing the vapor in the entrained air. When the windows were tightly closed, it was eliminated.

Boiler Room

Choking and plugging of the screw feeders and

feeder pipes were the chief causes of interruption in the fire room. It was on the second day that the tendency of the feeder lines to choke was most noticeable and this must be attributed to the moisture conditions encountered the night previous. In one instance, however, one of the lines to a burner stopped feeding when a piece of tarred paper lodged in it above the burner. No doubt this had been dropped into the pulverized fuel system accidentally. Operation of the furnace on which this occurred had been noticeably affected during the twenty-four hours previous to the removal of the pipe and the discovery of the source of trouble. A total of four feeder hours were lost during the test.

A high percentage of CO_2 was easily obtainable but could not be maintained for longer than an hour at a time, due to excessive slagging on the hearth. This slagging on the hearth and furnace bottoms may be attributed to flame characteristics resulting from certain draft conditions and can only be avoided by air regulation. On the newer type of Lopulco furnaces, as are in use at the Oneida Street plant, the method of air regulation is such that while admitting air for slag prevention, a large volume not needed for combustion, enters, by-passes the flame zone and is carried with the products of combustion in the form of excess air. The high percentage of excess air, together with a correspondingly low percentage of CO_2, as indicated by the flue gas analysis, was not determined by combustion considerations but rather by furnace limitations.

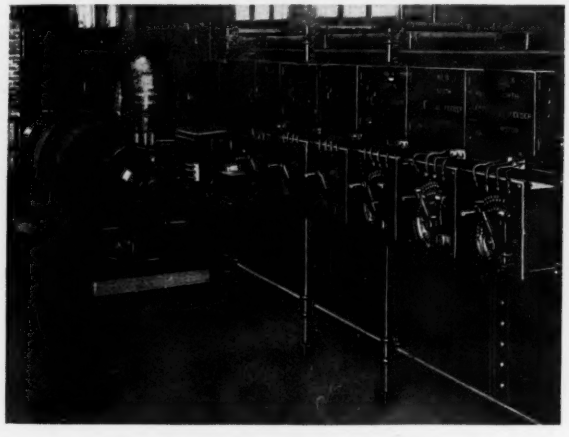


FIG. 6. MOTOR-DRIVEN BLOWER UNITS, SHOWING CONTROL RHEOSTATS FOR PULVERZIED COAL FEEDERS

No slagging occurred on the boiler tubes.

Flues were blown once every 8 hr.

Slag was withdrawn from the furnaces twice in 24 hr.

Back chamber ash was removed once every two days.

Due to the use of a single stack for the entire boiler plant, which includes six underfeed stoker boilers, no smoke observations were made. Smoke from the pulverized coal furnaces, however, has proved on all occasions when pulverized fuel alone is used, to be of a negligible quantity and appears in the form of a light yellow haze, which disappears within 25 yd. of the stack. The ash particles are so fine that no estimate can be made of the distance they are carried before being dropped from the air. No noticeable deposit has accumulated on or about the plant, although continuous operation has been carried on for more than a year.

T. M. E. R. & L. CO., TEST OF FIVE 468 H. P. BOILERS—NOS. 1 TO 5 INCLUSIVE ONEIDA STREET POWER PLANT

NOVEMBER 11-15, 1919

DIMENSIONS

1.	Number and kind of boilers	Five Edge Moor water tube boilers
2.	Kind of furnaces	Pulverized fuel burning furnaces
3.	Volume of combustion space, per boiler, cubic ft.	1678
4.	Water heating surface, sq. ft., per boiler	4680
5.	Superheating surface, sq. ft., per boiler (approximate)	594
	(a) Type of superheater	Foster
6.	Total heating surface, sq. ft., per boiler	5274
	(a) Ratio of water heating surface to volume of combustion space	1 to .359
	(b) Ratio to total heating surface to volume of combustion space	1 to .318

DATE, DURATION, ETC.

7.	Date	November 11-15, 1919
8.	Duration, hours	99
	(a) Boiler hours	495
9.	Kind and size of coal	Mixture—50% Yough. Scrgs. 50% East. Kentucky Scrgs.

AVERAGE PRESSURE, TEMPERATURES, ETC.

10.	Steam pressure by gage, lb. per sq. in	167.8
	(a) Barometric pressure, inches of mercury	29.49
11.	Steam pressure, absolute, lb. per sq. in	182.3
12.	Temperature of steam leaving superheaters, Deg. F.	441.9
	(a) Normal temperature saturated steam at above pressure, Deg. F.	374.2
13.	Temperatures of feed water entering boiler, Deg. F.	156.3
14.	Temperature of escaping gases, Deg F.	496.6
	(a) Temperature of flame above hearth, Deg. F.	2767
	(b) Temperature of furnace bottoms, Deg. F.	2180
15.	Draft under damper, inches of water	.173
16.	Draft in furnaces, inches of water	.031
17.	Air pressure at blower, inches of water	6.36
	(a) Pressure of air mixing with coal at screw feeder, inches of water	6.00
	(b) Pressure of air and coal mixture above burner outlet, inches of water	1.00
18.	State of weather	
	(a) Temperature outside, Deg. F.	28.
	(b) Relative humidity, per cent	72.
	(c) Room temperature, Deg. F.	75.7

QUALITY OF STEAM

19.	Number of degrees of superheat	67.7

TOTAL QUANTITIES

20.	Total weight of coal, as received, pounds	958,074
21.	Percentage of moisture	7.23
22.	Total weight of coal, as fired, pounds	894,800
23.	Percentage of moisture	.67
24.	Total weight of dry coal, pounds	888,805
25.	Slag, ash and refuse (dry, Laboratory basis) per cent	11.90
	(A) Withdrawn from furnace bottom, pounds total	9,770
	(a) Withdrawn from furnace bottom, pounds per hour per boiler	19.8
	(B) Withdrawn from tubes, flues and combustion chamber, pounds total	9,862
	(b) Withdrawn from tubes, flues and combustion chamber, pounds per hour, per boiler	20.0
	(C) Blown away with gases, pounds (Difference between Laboratory and actual weighed)	87,549
	(c) Blown away with gases, pounds per hour per boiler	176.8
	(D) Percentage of total lost with gases	82.8
	(E) Percentage of combustible in slag and ash recovered, per cent (Combined Analysis)	6.9
26.	Total combustible burned, pounds	781,622
27.	Total weight of water fed to boilers	8,249,536

28. Factor of evaporation	1.1473
29. Total equivalent evaporation from and at 212° F., pounds	9,464,693

HOURLY QUANTITIES AND RATES

30. Dry coal per hour, pounds	8,978
(a) Dry coal per hour, per boiler, pounds	1,796
31. Water evaporated per hour, pounds actual	83,328
(a) Water evaporated per hour, per boiler, pounds actual	16,666
32. Equivalent evaporation per hour from and at 212° F., pounds	95,603
(a) Equivalent evaporation per hour per boiler from and at 212° F., pounds	19,121
33. Equivalent evaporation per hour from and at 212° F., per sq. ft. of water heating surface lbs.	4.09

CAPACITY

34. Evaporation per hour, from and at 212° F., per boiler, pounds	19,121
(a) Boiler horsepower developed	554
35. Rated capacity per hour from and at 212° F., per boiler, pounds	16,146
(a) Rated boiler horsepower	468
36. Percentage of rated capacity developed	118.4

ECONOMY

37. Water fed per pound of coal, as received, lb.	8.611
38. Water fed per pound of coal, as fired, lb.	9.219
39. Water evaporated per pound of coal dry, lb.	9.282
40. Water exaporated per pound of combustible, lb.	10.554
41. Equivalent evaporation from and at 212° F., per pound of coal, as received, pounds	9.879
42. Equivalent evaporation from and at 212° F., per pound of coal, as fired, pounds	10.577
43. Equivalent evaporation from and at 212° F., per pound of coal dry, pounds	10.649
44. Equivalent evaporation from and at 212° F., per pound of combustible, pounds	12.109

GROSS EFFICIENCIES

45. Calorific value of 1 pound of dry coal by calorimeter, B.t.u.	12.810
46. Gross efficiency of boiler and furnace, per cent.	80.67
47. Efficiency of furnace, per cent	99.79

SMOKE DATA

48. See notes.

ANALYSES OF FLUE GASES

49. Carbon dioxide, per cent	12.26
50. Oxygen, per cent	6.82
51. Carbon monoxide, per cent	.00

ANALYSES OF COAL

52. Proximate.

	As Received	As Fired	Dry
(a) Moisture	7.23	.67	....
(b) Volatile	32.13	34.40	34.63
(c) Fixed Carbon	49.60	53.11	53.47
(d) Ash	11.04	11.82	11.90
	100.00	100.00	100.00

(e) Sulphur separately determined referred to dry coal	1.62

53. Ultimate Analyses.

(a) Carbon	73.57
(b) Hydrogen	4.35
(c) Oxygen	7.22
(d) Nitrogen	1.34
(e) Sulphur	1.62
(f) Ash	11.90
	100.00

54. Analyses of—

	Slag	Combustion Ash Retained	Combustion Ash Lost
(a) Moisture	.00	13.00	
(b) Combustible	.59	13.76	
			Unknown
(c) Earthly matter	99.41	86.24	

HEAT BALANCE

	Method—A. S. M. E. B.t.u.	A. S. M. E. Per Cent.	Uehling B.t.u.	Uehling Per Cent.
(a) Heat absorbed by the boiler	10334	80.67	10334	80.67
(b) Loss due to evaporation or moisture in coal	8	.06	8	.06
(c) Loss due to heat carried away by steam formed by the burning of hydrogen	486	3.79	463	3.61
(d) Loss due to heat carried away in dry flue gases	1527	11.93	1551	12.11
(e) Loss due to carbon monoxide	0	.00	0	.00
(f) Loss due to combustible in ash	23	.18	23	.18
(g) Loss due to heating moisture in air	39	.30	39	.30
(h) Loss due to combustible carried away with flue gases, unconsumed hydrogen, hydrocarbons, radiation and unaccounted for	393	3.07	393	3.07
(i) Total calorific value of 1 lb. of dry coal	12810		12810	
(j) Total per cent		100.00		100.00

TEST ON FUEL PULVERIZING EQUIPMENT ONEIDA STREET POWER PLANT

NOVEMBER 11-15, 1919

GENERAL CONDITIONS—AVERAGE TEMPERATURES, ETC.

1. Temperature of air entering dryer furnace, Deg. F.	93.8
2. Temperature of gases leaving dryer, Deg. F.	181.18
3. Humidity of outside air, per cent	72.0
4. Draft through dryer, inches of water	.77
5. Vacuum in pulverizers, inches of water—No. 1, 5.0; No. 2, 5.16. Average	5.08

COAL TEMPERATURES, MOISTURES AND FINENESS

6. Temperature of coal entering dryer, Deg. F.	88.2
7. Temperature of coal leaving dryer, Deg. F.	237.9
8. Temperature of coal leaving pulverizers, Deg. F.	169.7
9. Moisture of coal entering dryer, per cent.	5.59
10. Moisture of coal leaving dryer, per cent.	1.61
11. Moisture of coal leaving pulverizers, per cent.	1.03
12. Fineness of pulverized coal, 200 mesh, per cent	81.30
13. Fineness of pulverized coal, 100 mesh, per cent	97.40
14. Fineness of pulverized coal, 80 mesh, per cent	99.30
15. Fineness of pulverized coal, 60 mesh, per cent	100.00

TOTAL AND HOURLY QUANTITIES

CRUSHER

16. Total coal crushed, as received at crusher, tons	479.0
17. Coal crushed per hour, as received, tons	17.5

DRYER

18. Total coal dried, as received at dryer, tons	471.2
19. Total coal dried per hour of dryer operation, as received, tons	6.7

PULVERIZER

20. Total coal pulverized, coal from dryer, tons	447.4
21. Capacity of pulverizer per hour, tons	5.0
22. Coal pulverized per hour, dry, tons, total	7.90
23. Coal pulverized per hour, dry, tons, per mill	3.95
24. Coal pulverized per hour, per mill, as received at plant, tons	4.23

CONSUMPTION OF LUBRICANTS

25. Total grease consumed by elevators and conveyors, pounds	6.0
26. Grease per ton of coal, as received, pounds	.012
27. Total grease consumed by pulverizers, pounds	13.0
28. Grease consumed per pulverizer per hour of operation, pounds	.112
29. Grease consumed per pulverizer per ton of coal pulverized, pounds	.028
30. Grease consumed on all equipment per ton of coal, as received, pounds	.040
31. Total oil consumed on all equipment, quarts	17.0
32. Oil consumed per ton of coal as received, quarts	.036

ELECTRIC ENERGY AND COAL CONSUMPTION

33. Total energy consumed by crusher and green coal elevator	220.0

34.	Energy per ton of coal, as received, kw.-hr.	.47
35.	Total energy consumed by dryer, kw.-hr.	735
36.	Energy per ton of coal, as received, consumed by dryer	1.53
37.	Total energy consumed by pulverizers, kw.-hr. (Fan and drive motor)	8010
		Mill No. 1 Mill No. 2
38.	Motor input per hour, hp.	93.8 90.2
39.	Energy consumed by pulverizer per ton of coal, as received, kw.-hr.	16.72
40.	Energy consumed by pulverizer per ton of coal, as pulverized, kw.-hr.	17.90
41.	Total energy consumed by pulverized coal conveyors, feeder blowers and feeders	1789
42.	Total energy consumed by pulverized coal conveyors, feeder blowers and feeders per ton of coal as received	3.73
43.	Total energy consumed by pulverized coal conveyors, feeder blowers and feeders per ton of coal as fired	4.00
44.	Total energy consumed by all equipment on preparation and firing of pulverized fuel, kw.-hr.	10754
45.	Energy per ton of coal, as received, kw.-hr.—Grand Total	22.45
46.	Coal equivalent for this energy at 1.5 lb. coal per kw.-hr. lb.	33.68
47.	Total coal used in dryer furnace	12291
48.	Coal per ton of fuel dried, pounds (based on coal as received)	25.66
49.	Total coal and equivalent consumed in preparation and firing of one ton of pulverized fuel, lb	59.34
	COST OF PREPARATION—OPERATION AND MAINTENANCE	
50.	Cost of labor per ton of coal—operation	$ .143
51.	Cost of fuel for drying plus fuel for electric energy Coal at $4.00 per ton	.119
52.	Cost of lubricants per ton of coal—Grease at 9c per lb.	.007
53.	Cost of labor per ton of coal—maintenance	.036
54.	Cost of material—maintenance	.020
55.	Total cost per ton of coal	.325

Note: Item 50 is based on the labor required to pulverize coal sufficient for five boilers through a twenty-four hour run per day.

SUMMARY SHEET

ELECTRIC ENERGY AND FUEL CONSUMPTION PER TON OF COAL PULVERIZED

1.	Energy consumed by conveyors, crushers, elevators, dryers, blowers and feeders, kw.-hr.	5.73
2.	Energy consumed by pulverizer, kw.-hr.	16.72
3.	Total energy, kw.-hr.	22.45
4.	Coal equivalent at 1.5 lb. per kw.-hr., lb.	33.68
5.	Coal consumed in dryer furnace, lb. per ton of fuel dried	25.66
6.	Total coal and equivalent, lb.	59.34
7.	Gross efficiency less deductions for total coal and equivalent—Item 6	78.36

COST OF FUEL PREPARATION, FIRING AND ASH DISPOSAL

8.	Labor—Coal preparation	$ .143
9.	Labor—Firing	.112
10.	Labor—Ash removal	.025
11.	Dryer Fuel—Coal at $4.00 per ton	.051
12.	Electric Energy—Coal per kw.-hr. at 1.5 lb.	.068
13.	Maintenance (Labor at 3.6c—Material at 2.0c manufacturer's estimate—Lubricants at .7c)	.063
14.	Total cost of Fuel Preparation, Firing, Ash Disposal and Maintenance	.462
15.	Price of coal as purchased, per ton	4.000
16.	Total cost	4.462

EFFICIENCIES

17.	Actual Gross Efficiency, per cent.	80.67
18.	Net efficiency after all incidental costs have been accounted for, per cent.	72.32

The tests were conducted by the engineers of the T. M. E. R. & L. Co., being directly supervised by Fred Dornbrook, assisted by Messrs. Schubert and Mistele, Test Engineers. Paul Thompson, Technical Engineer of Power Plants, Detroit Edison Company was present throughout the four days, as an observer.

Progress of Power Engineering---II

A REVIEW OF POWER DEVELOPMENTS IN ASIA, AUSTRALIA, AND SOUTH AND CENTRAL AMERICA DURING THE LAST FEW YEARS, AND THE POSSIBILITIES FOR FUTURE EXPANSION. BY L. W. ALWYN-SCHMIDT

RECENT development of power enterprise outside of Europe differs from contemporary European development insofar as it has taken place mostly in countries that had no industrial activity of their own, or where industrial enterprise is still in its beginning. The whole character of this development is vastly different from that in Europe; it leads, while that in Europe follows. Without the previous introduction of power there can be no economic progress. Power engineering, therefore, is of great importance in these countries; it is their very life.

Power development has practically stood still outside of Europe during the last few years. A few large enterprises excepted, no important development has been taken in hand, and those which have been finished were done only under great difficulties. Two principal causes have been responsible, one, the lack of capital, the other lack of equipment. Asia, Australia and South America before the war lived financially only from the breadcrumbs that fell from the table of Europe. As the earth derives its light from the sun, so these regions of the world lived in the sunshine of the financial riches of Europe which dispensed them according to its best opinion. Progress of any kind, therefore, was necessarily slow, and it took place only where Europe permitted. During the war, this dependency upon Europe was brought more than ever to the notice of the non-European countries. European financial assistance, after having flown pretty regularly in former times, suddenly disappeared entirely and with it all initiative for the construction of public utilities ended. But even were the money obtainable, there was the other impediment of shortage of equipment. England and Germany, the principal sources of supply for power equipment of all kind, were engaged in the war and too busy to trouble about industrial conditions in other countries, and the American industry was not yet quite ready to take its place in the world's markets.

But the war has also brought the remedy for this situation; it is another world which is now faced by the power industry. First of all Europe has no longer a monopoly upon the world's money supply. America has taken the place of Europe in this respect and the former borrowers of Europe have not only been able in many instances to return the loans but have lent money themselves. Asia, Australia, South and Central America have grown rich during the war. They have sold their products at high prices to Europe and have accumulated large credits which they can now employ to further their own interests. Furthermore, money has come to these countries directly. The merchants and farmers are no longer forced to look to Europe for advances to handle their production; they now have that money at their disposal. The South American merchant has become an

investor upon a large scale and he has learned to invest in the public utilities of his respective country. Similar changes have come to all the other nations outside Europe and a great opportunity, therefore, has arisen for these countries to develop their resources.

American Power Engineering Has Become International Factor

The world's power engineers are no longer relying entirely upon Europe for equipment. America has completed its foreign trading organization and the American power equipment industry has become an important factor in power development. During the second half of the war it fell to the lot of the American industry to supply large quantities of power material, electrical, gas, and steam, to other countries. Shipments have been slow in many cases, but it has been acknowledged frequently that, failing the American help, there would have been no hope for completing some of the most important power developments that have been finished during the war.

This puts an entirely new complexion upon power construction in non-European countries. A new competitor means greater independence on the side of the purchaser, and the American power industry has already shown that it knows how to handle the problems of its foreign customers. In fact, many of these problems are the problems of our own country. The risks of harnessing big streams in territories difficult of access, of building enormous dams, of constructing high power transmission lines, so often met by our own engineers right in the United States, are only duplicated in other countries. Our advice, therefore, will be just as valuable to our prospective purchasers as the goods themselves. To make ourselves really useful now, it will be necessary for us to familiarize our industry with the conditions in our new markets. We must study new foreign developments as we have studied our own, we must especially know what is going on in the foreign power field outside of Europe.

News about new developments and possibilities for power construction comes from all corners of the world, and it is especially significant of the present state of development that many new countries have entered into the realm of industrial exploitation of their natural power resources.

A Palestine Power Scheme

It is interesting to read of a scheme of irrigation and power production in Palestine that deserves attention if only for the magnitude of its conception. Mr. Hiorth, a Norwegian power engineer, proposes to run a tunnel 37 mi. long to the Dead Sea. The tunnel is to pass underneath Jerusalem and will reach the Jordan valley above the level of the Dead Sea, which is lower than that of the Mediterranean. The water will then be directed by means of a pipe line to a power station which the promotors propose to utilize as follows: (1) for the production of nitrate from the air, for the extraction of salt from the Dead Sea and for mining operations; (2) for the distribution of light and power; (3) for a pumping plant on the Sea Genezareth which will supply water to a large part of Palestine which is only imperfectly irrigated at the present time. Large tracts of country will be reclaimed in this manner for agriculture. The cost of such an enterprise, of course, would be considerable, but it does not seem to be so large as to be prohibitive. The tunnel is expected to cost $40,000,000. The power plant and irrigation works will add another $20,000,000. To make such an investment pay, it must, no doubt, produce very exceptional results; but if the company should decide to go into land development, and provide capital for industrial enterprises, taking its power, there should be sufficient income to pay the interest on such an investment and for the operation of the various enterprises connected with it. This development is typical of the new conception of power enterprise, where the power station leads the industry and provides the possibilities for its existence. It is in this respect representative of many similar power developments that are proposed at the present moment in Asia and in other parts of the world.

Asiatic Development

England is busy developing schemes of this character in India. Irrigation on a large scale has formed one of the main interests of the English Colonial Government during the last years. It has carried out, only quite lately, the large irrigation project of the Nile which has added thousands of acres of cotton fields to those of Egypt and a number of big enterprises are nearing completion in India and elsewhere under the guidance of the English Colonial Government. The present Indian proposal deals with the irrigation of the Punjab. The problems connected with this enterprise are rather extensive. Studies have been made for several years and one after another of the proposed schemes has had to be abandoned as impossible of execution under present circumstances. Now a new one is under contemplation which requires the construction of a dam in the Bhakra Gorge. This project, together with the other four which are to complete the whole scheme, will entail a total outlay of $110,000,000 and will provide a secure water supply for 6,000,000 acres of land. The stored water will be used for irrigation and for power development.

In the meantime, the demand for power increases all over India and the East. Singapore in the Straits Settlements requires urgently additional power facilities and a new power station is contemplated in that city. The work on this scheme has been delayed by the war, as it was impossible to secure materials and general supplies. As this obstacle is now removed, it is expected that construction will proceed quickly and that all the consumers will be able to receive the required power.

Chinese power development has suffered in many respects from the war. Coal that was obtainable under ordinary circumstances in satisfactory quantities could not be had and restrictions had to be enforced. So it became necessary to shut down on sky signs in the ports and the takings of the various electrical enterprises have, therefore, suffered. The situation is now improving. The power supply of China, as far as electrical power distribution is concerned, is still principally in the hands of private enterprises. Some of the large mines and steel works have their own power stations and have distributed power to cities and industrial enterprises in their districts. The railroads have also been interested

in electrical power development. A great number of the smaller central stations are operated by Diesel motors. Water power is still made little use of as the large Chinese rivers offer few opportunities for that purpose. Considering the great industrial possibilities of China and its vast resources of cheap labor it may be expected, however, that China will soon show a considerable demand for industrial power which will have to be supplied in one manner or another. There has been a fair flow of orders for steam power equipment in the direction of the United States during the war and some of the finest dynamos recently installed in Chinese electrical central stations have been of American make.

Japanese engineers are said to be frequently in China and several of the smaller central stations are already operated with the aid of Japanese capital. The Japanese no doubt have the right conception of the power problem in their own country. The leading principle in all Japanese power development, in fact, is that no power supply is good unless it is also cheap. Recent increases in power consumption rates that have been necessary, owing to the increasing operation cost, have been very small compared with the rate additions that have been enforced in other countries. But Japanese power engineers begin to wonder whether the growth of the industry can be maintained under these circumstances. Japan had one very unsatisfactory experience in power industry financing after the end of the Japanese war. Similar to present conditions, the war had caused a rather excessive industrial development all over Japan that could be sustained only by the extension of considerable credits. Many new power plants were put in operation during that time, some of which failed soon after the cessation of hostilities. As the result, there was a slump in power financing. Japan apparently benefited by her experience and will put a curb on further power expansion until the industrial activity of the country begins to catch up again with the supply.

Activity in New Zealand

The most active field of power development during the war was New Zealand. Hydroelectrical power generation in New Zealand is a governmental enterprise and the government also is mostly responsible for the early completion of the large Lake Coleridge power station in the South Island that was put into operation a few years ago. The construction of this large development proved to be a difficult engineering problem, as most of the material had to be obtained during the war. The necessary credits for developing three power sites in the North Island are now under consideration and $725,000 was appropriated for preliminary work in connection with these. The total development when finished will produce 160,000 hp. and the cost is estimated to be $35,000,000. To complete its scheme of power supply, the government has bought the Horahora Electric Power Works from the Waihi Gold Mining Co. The present plant is able to develop 9000 hp., but it is intended to extend it and to add another 6000 hp. to the output. This will come handy in relieving the present shortage of power supply in the city of Auckland where the two local power plants are no longer sufficient to fill the needs of the growing industry and the city lighting and tramway system. Electrical power of course will not be sufficient to satisfy all the power wants of the country but the development of the power sources included in the present plan will help a good deal in that direction. Coal is still difficult to obtain and a serious coal shortage would result from the slightest provocation, like a breakdown of the transportation system, a strike, or any similar occurrence. Much of the electrical equipment that was employed in constructing the hydroelectric power stations of New Zealand was obtained in the United States.

Not Much Activity in South America

In South America no large developments are under way at the present time. Most of the enterprises that are under construction are of a local nature only; but the actual possibilities are doubtless considerable. The Andes and the rapid eastward descent of the middle South American plateau offer excellent opportunities for the construction of hydroelectric power stations and with the return of security to the investor, there will also come the time when some of these can be taken in hand. In Brazil, much progress has been made with the electrification of the governmental railroads, but no comprehensive plan so far has been developed. The electrical central stations in the interior of South America are operated today mostly by Diesel motors, as these provide the easiest means of bringing the fuel to the motors. Coal is used practically only in the ports and in cities that can be reached by water. This has acted as a serious impediment to power development in South America. A careful study of all the hydroelectric possibilities, therefore, is under way, but is hampered by the astonishing lack of information in the possession of the South American governments about the locations for such enterprises. Various commissions have been appointed for that purpose and these are proceeding now to survey the water powers of the continent with a view to selecting the most promising for the erection of power plants. The natural powers lying dormant at present all over South America are very considerable and if developed will practically end the present power difficulties of its industries, railroads and cities.

Read about the achievements of great men. Follow word for word the nobleness of their character, the tremendousness of their power, the sublimeness of their aim. You feel in the ideal the very same which they so wonderfully wrought in the real. Place yourself in mental contact with genius and greatness in any form or manner, and you are invariably inspired with a desire to go and do likewise. You will aim higher than before; you will work with greater determination than before; and every dormant faculty within you will come forth, one after the other, to work for some greater and nobler goal. There is greatness in man. When you meet greatness in others, the greatness in yourself is awakened.—Christian D. Larson, in "Business Inspirations."

Journal of Commerce announces that aggregate authorized capitalization of shipping and shipbuilding companies organized during January amounted to $76,305,000, this figure standing as second highest investment in new shipping enterprise for any one month since outbreak of war in 1914.

Eliminating Fuel Waste in Power Plants

SUGGESTIONS ON THE USE OF EXHAUST STEAM FOR HEATING A NUMBER OF DWELLINGS AS A MEANS OF SAVING COAL. BY CHARLES L. HUBBARD

WHILE PASSING through a section of a large New England city recently, I particularly noticed a modern, two-story brick shop flanked on either side by a row of three-story tenement houses, presumably occupied, in part at least, by employes of the shop. The thing which especially attracted my attention, however, was the cloud of steam issuing from a pipe projecting through the wall of the power house, which, on investigation, proved to be the exhaust from a high-speed engine. The steam was being discharged horizontally for 20 ft. or more from a 5-in. pipe. If circumstances had permitted, it would have been interesting to have visited the shop and learned the method employed for heating, whether exhaust steam was used or live steam taken directly from the boilers.

Let us approximate the quantity of heat going to waste in that exhaust steam. A 5-in. straight pipe, 40 ft. long, supplied with steam at 1 lb. pressure and discharging into the atmosphere will deliver about 6000 lb. per hour. Suppose this steam could be conveyed

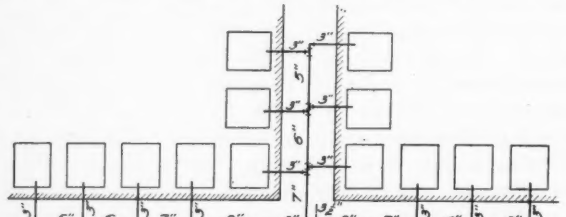


FIG. 1. LAYOUT OF EXHAUST HEATING PLANT FOR HEATING A NUMBER OF HOUSES

to the basement of the adjacent building with a radiation loss in well insulated pipes not exceeding 15 per cent, leaving available $6000 \times 0.85 = 5100$ lb. of steam at, say, 1 lb. pressure and containing $5100 \times 968 = 4{,}936{,}800$ heat units. One pound of anthracite coal contains about 13,000 heat units, and if 45 per cent of these are utilized in the heating boiler of the average tenement house, then the heat wasted is equivalent to

$$\frac{4{,}936{,}800}{13{,}000 \times 0.45} = 844 \text{ lb. of coal per hour or } 844 \times 8 = 6752 \text{ lb.,}$$

or 3.375 tons per working day, when used under the conditions noted above.

Suppose this steam was piped to a sufficient number of houses to utilize, in zero weather, the full quantity now wasted, and as the outside temperature rose, and radiators were closed, the surplus was exhausted through a relief valve. For New England, and similar climates, it is customary to assume a heating season of about 7 mo. and an average outside temperature of approximately 35 deg., when making fuel estimates.

Under these conditions, we have a heating season of 210 days and would be able to utilize one-half the exhaust now wasted, under the conditions assumed. If the heat equivalent of $3.375 \div 2$, or 1,688 tons of coal, can be utilized per day for the entire heating season, it will amount to a total of $1.688 \times 210 = 354$ tons per year, worth to the tenants, at present prices, about $354 \times 13 = \$4602$. If steam could be supplied to the occupants of the houses at the cost of coal, thus eliminating all care of furnaces, handling of ashes, etc., it would prove an attractive inducement.

The number of buildings which can be supplied will, of course, depend upon the amount of radiation which they contain. Assuming for example that each flat has 200 sq. ft., then each six-flat building will contain $200 \times 6 = 1200$ sq. ft., and increasing this 10 per cent for piping will give a total of $1200 \times 1.1 = 1320$. If the radiation has an efficiency of 250 heat units per square foot per hour, then $250 \div 968 = 0.26$ lb. of steam will be condensed per square foot of radiation per hour, or $1320 \times 0.26 = 340$ lb. per building. The total available steam is 5100 lb. per hour; hence $5100 \div 340 = 15$ buildings of the type under consideration may be heated 8 hr. per day in zero weather with the steam now going to waste, and with a saving of nearly $5000 per year in cost of coal.

In many cases, a large proportion of the exhaust steam is employed in heating the buildings of the plant; but in other instances the power requirements may be large in proportion to the heating load and there will be surplus exhaust going to waste. If the plant is located in a thickly settled section, it may be possible to dispose of this to advantage in a manner similar to the case in hand and make it pay a good dividend upon the cost of installing the mains. Whether or not it will pay to attempt to return the condensate to the boilers will depend somewhat upon the grades and the cost of installing a second line of piping. If the position of the power house is such that the condensate will flow back to a receiving tank by gravity, then this matter should be considered and figures obtained for installing the extra line of pipe.

Steam can be distributed at the lowest pressure which will circulate freely through the most distant radiators and the condensation from each building discharged into the return main through a siphon trap.

Going back to the original proposition, it should be noted that utilizing the exhaust only provides for heat 8 hr. per day, so that it will be necessary to piece this out at both ends by the use of live steam. This will not require any additional apparatus, unless it be a regulating valve for reducing the pressure, as the boiler power will be ample for all heating purposes when the engine is not running. It will be necessary, however, to get up steam earlier in the morning and to carry it for 4 or 5 hr. later at night, thus calling for the services of an assistant fireman.

In the illustration given it was proposed to connect up only such a number of houses as could be cared for

by the available exhaust in zero weather, and waste the surplus when the outside temperature was above that point, in order not to complicate matters in any way. If, however, this scheme is to be carried out on any considerable scale it would be best to connect with as many buildings as could be cared for at a much higher outside temperature and make up the deficiency by admitting live steam when the temperature fell below that point.

Suppose as many houses were connected with the system as could be heated with the available exhaust when the outside temperature was 20 deg., and live steam was used to piece out when it fell below that point; no exhaust would then be wasted until the temperature rose above 20 deg., and the loss for the season would be greatly reduced over the original proposition.

With the distributing mains in place, heating by live steam to a certain extent would prove profitable on a basis of the ordinary cost of heat to the consumer, owing to the higher efficiency of the power boilers (60 to 70 per cent) as against that of the house-heating boilers (40 to 50 per cent). Furthermore, the cost of coal per ton would be somewhat less for the power plant, due to the cheaper grades of fuel which it is possible to use and also to the benefits to be derived from buying in larger quantities. In cases of strikes, and coal shortage from other causes, the power plant is more likely to have a larger supply on hand than the average householder, and furthermore, the same coal is made to do the double duty of furnishing both power and heat.

Whether or not additional boilers would be required if live steam were required for heating at temperatures below 20 or 25 deg. would, of course, depend upon local conditions. In many cases, it is possible to increase the boiler capacity 50 to 100 per cent without appreciable loss of efficiency by installing mechanical soot blowers to keep the heating surfaces clean, combined with more efficient methods of firing. If the draft is not sufficient to burn the required amount of fuel at times of maximum load, it may often be strengthened sufficiently by installing an under-grate blower of the "turbo" type, for temporary use as may be required.

Let us see what increase in boiler power would be required in the present proposition if a sufficient number of houses were included on the line to use all of the exhaust now going to waste, with an outside temperature of 20 deg., instead of zero, as was originally taken. The steam being exhausted to the atmosphere was assumed to be 6000 lb. per hr. If 20 per cent of that supplied to the engine was used in doing work and lost in radiation, etc., then $6000 \div 0.8 = 7500$ lb. per hr. was required of the boilers. At a temperature of zero outside, or a difference of 70—0=70 deg. between inside and outside, the steam requirements of each house were found to be 340 lb. per hr. With an outside temperature of 20 deg. this difference would be $70 - 20 = 50$ deg., and the steam requirements would be only $\frac{50}{70} = 0.7$ as much as before, or $340 \times 0.7 = 238$ lb. per hr. Under these conditions, when the outside temperature dropped to zero, it would be necessary to supply each house with $340 - 238 = 102$ lb. of live steam per hour, which, increased 15 per cent for line losses, would be $102 \times 1.15 = 117$ lb.

Going back a little, we found that only 0.7 as much steam was required for heating when it was 20 deg. outside as when it was zero; hence, $15 \div 0.7 = 21$ houses, instead of 15, could be heated at this higher outside temperature with the steam now going to waste. If 117 lb. of live steam are required per hour per building in zero weather for supplementing the exhaust, then a total of $117 \times 21 = 2457$ lb. will be required, making the total load on the boilers $7500 + 2457 = 9957$ lb. per hour, or an increase of $9957 \div 7500 = 1.33$, or 33 per cent, which should easily be possible by forcing, if the original load was carried on a nominal rating.

Now, let us make a preliminary plan, showing the method of laying the mains and making the necessary connections, assuming the grades to be such that the condensate will flow back to a receiving tank in the boiler by placing it in a pit.

The general layout of the underground pipe mains is shown in Fig. 1, with the sizes of the supplies marked on the plan. These sizes are for a low-pressure distributor not exceeding about 2 lb., so as not to throw an increased back-pressure on the engines over that which might naturally be expected when exhausting outboard. The main returns are also indicated in Fig. 1, and the

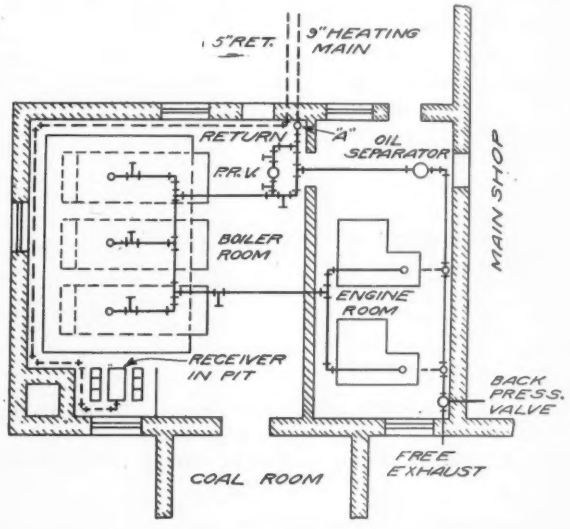


FIG. 2. ARRANGEMENT OF PIPING IN THE POWER PLANT

branches to the individual houses in Fig. 3. The underground mains, both supply and return, should be carried inside a tile conduit, packed with insulating material, or protected by other methods suitable for this class of work.

Typical power house connections are shown in Fig. 2. A back-pressure valve is placed in the outboard exhaust pipe, and the line extended in the other direction to the 9-in. heading main, through an oil separator. Live steam connection is made with the main header over the boilers, and a pressure-reducing valve and bypass are provided, as indicated on the drawing. This piping is all overhead and drops into the underground trench at the point "A."

A typical basement layout in one of the houses, in which each of the six apartments has its own boiler, is shown in Fig. 3. The old boilers and all of the piping

are allowed to remain in place, and connection made the three extreme ends of the line, the condensation may from the central system as shown on the drawing. At discharge directly into the underground return mains, because the pressure is lowest at these points. In all intermediate buildings a siphon trap should be inserted, as shown in Fig. 3, to balance any inequality of pressure and prevent the holding back of condensate from points beyond.

In case any of the houses are heated by a single boiler, and have janitor service so far as the heating goes, the pipe connections will be much more simple, as indicated in Fig. 4. The size of the return in this case is given for a vacuum system, which would be necessary if the grades were such that the condensate could not drain readily to the boiler room.

In a perfectly level location it would be better to use a vucuum pump on the main return, discharging into the receiving tank. This would make it unnecessary to pit the receiver and make the return more positive. Thermostatic return valves would not be necessary on the radiators, as the action of each building would be the same as when working under a low-pressure gravity

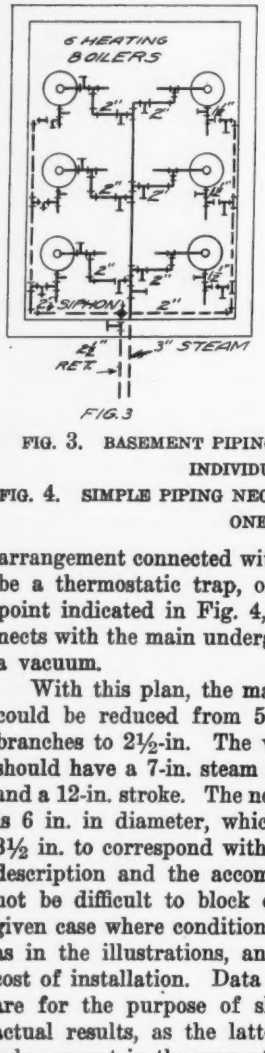


FIG. 3

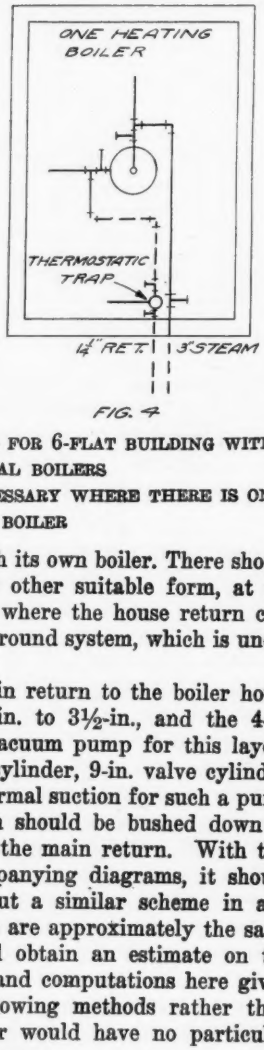


FIG. 4

FIG. 3. BASEMENT PIPING FOR 6-FLAT BUILDING WITH INDIVIDUAL BOILERS

FIG. 4. SIMPLE PIPING NECESSARY WHERE THERE IS ONLY ONE BOILER

arrangement connected with its own boiler. There should be a thermostatic trap, or other suitable form, at the point indicated in Fig. 4, where the house return connects with the main underground system, which is under a vacuum.

With this plan, the main return to the boiler house could be reduced from 5-in. to 3½-in., and the 4-in. branches to 2½-in. The vacuum pump for this layout should have a 7-in. steam cylinder, 9-in. valve cylinder, and a 12-in. stroke. The normal suction for such a pump is 6 in. in diameter, which should be bushed down to 3½ in. to correspond with the main return. With this description and the accompanying diagrams, it should not be difficult to block out a similar scheme in any given case where conditions are approximately the same as in the illustrations, and obtain an estimate on the cost of installation. Data and computations here given are for the purpose of showing methods rather than actual results, as the latter would have no particular value except in the present case.

Safe Speeds During Turbine Runaway Tests

SO WELL recognized is the value of the periodic inspection and test on the overspeed tripping device of the turbine governor mechanism in the companies operating many turbines, that it is religiously made as often as once a week in most plants. The emergency trip mechanism may easily lose its delicate adjustment and either operate at too great a turbine speed or fail to operate at all, and occasional corrections on its adjustment are necessary to keep it operative within the desired range of speed values.

The overspeed test is made by bringing the turbine to speed, then by making its hydraulic governor inoperative, allowing it to accelerate until the emergency trip operates and closes the throttle valve. This tripping point will be at somewhere from four to thirteen per cent excess speed. One of the objections to the frequent testing of the emergency trip on large units is the possible strain on the unit due to this excessive rotative speed.

This has been overcome in one plant by the establishing of an artificial normal speed during the runaway test by the addition of a counterweight to the tripping block of the emergency-trip ring on the governor shaft, thereby increasing the centrifugal force developed at the tripping block for a given speed. The counterweight is a small piece of metal that is attached to the block by a screw. The counterweight was furnished by the turbine manufacturer, and on test was found to effect a 12 per cent reduction in turbine speed while developing the same centrifugal force at the tripping block as at normal turbine speed without it.

This makes the full speed of the turbine only 88 per cent of normal during the test; then if the emergency trip functions at, say, 96 per cent of normal speed, this is equivalent to 96 minus 88, or 8 per cent excess speed, and the trip may be said to operate at that figure of 8 per cent overspeed. The unit, of course, must be at rest when the counterweight is attached or removed, and the turbine rotor must be turned over until the tripping block is brought to a position where it is convenient to reach.

PROF. H. H. STOCK, of University of Illinois, is presenting storage possibilities of soft coal before American Institute of Mining and Metallurgical Engineers, New York, stressed the fact that purchase and storage of coal during spring and summer months were absolutely necessary for supply regularity or production regularity. S. L. Yerkes stated that car shortage stands out above all troubles of the coal industry. "Never in the history of the coal industry," he said, "has a surplus of approximately 250,000 open tops cars available for coal loading been wiped out and changed to a shortage of approximately 75,000 cars in 8 mo.; yet such are the facts, as on April 1, 1919, there was an approximate surplus of 250,000 open top cars, while today a fair estimate of the shortage is 75,000 cars."

WHAT other engineers find worth while will in many cases prove worth while for you.

CLIFTON H. WHEELER

AT FIFTEEN HE ENTERED THE SHIPPING BUSINESS. LATER BECAME INTERESTED IN CONDENSERS, AND DEVELOPED NEW TYPES. AN ACTIVE EXECUTIVE AND SUCCESSFUL ENGINEER. BY T. ROBERTS

WHAT is an engineer? Webster defines such a man as one versed in or practicing any branch of engineering.

But what is a successful engineer? Briefly, it is he who has acquired advanced knowledge through study and practice, he who has a forward look, a genial smile, and the ability to utilize opportunities—a man of the type of Clifton H. Wheeler. His record is one that any young engineer or business man can study to advantage.

Owing to the death of his parents when he was quite young, Mr. Wheeler's school days were interrupted and at the age of fifteen he started working in the importing and exporting house of Lawrence Giles & Co., New York. Though he advanced quickly, he was not satisfied with the future prospects of that concern and so formed a partnership with an old time stevedore under the firm name of Wilson & Wheeler.

Mr. Wheeler did not like the practice then prevailing whereby each captain of a ship arranged for its loading and unloading, as it was neither a clean nor a satisfactory condition for his concern or the shipowner. He inaugurated a new plan in that business, went to England and succeeded in closing contracts with two large owners to handle their ships in New York harbor. This started a movement which led to all shipowners making similar agreements and in turn revolutionized the business in New York.

About this time his brother, S. Merriam Wheeler, who was a marine pump expert and engineer well known in marine circles, showed him the advantages of the surface condenser and its adaptability for stationary plants. Immediately he grasped the possibilities of the business and its future. This was early in the year 1888. He then left the loading and unloading of ships to devote his entire time to condensers.

At that time, surface condensers were used only in salt water service on ships. Where condensing engines were sold in this country only jet type condensers were used and they were built in most cases by the engine builders and were of different designs, all more or less unsuccessful. C. H. Wheeler was able to see a great future for the surface condenser for stationary plants and started out to build up this demand by education of college students and informing the engine builders and users of its advantages. Success was forthcoming after much hard work, and he organized the Wheeler Condenser & Engineering Co. in 1891, serving as president and general manager of that company until 1904. That the business was established on a firm basis and during an exceptionally trying period of business in this country was due in a great measure to his enterprise and foresight in developing the condenser field in Great Britain and her colonies. There the American design and equipment quickly supplanted the older types of condensers, and for several years he equipped all the principal power plants in Great Britain with condensers. This was all done by his individual efforts, involving many trips to England and other countries of Europe; and at the same time, Edwin Reynolds was making similar progress with the E. P. Allis Co. engines.

With the advent of the steam turbine came the demand for higher vacuum. Using foresight again and taking advantage of another opportunity, Mr. Wheeler secured the American rights for the Edwards Air Pump.

In 1905 he took charge of a bankrupt pumping engine plant, the Barr Pump Co. of Philadelphia, and resumed once more the building up of another condenser concern, the C. H. Wheeler Mfg. Co., to develop new and improved types of condensers for higher

vacuum. He introduced successfully the reciprocating suction valveless wet vacuum pump, the rotary positive displacement wet vacuum air pump, and the hydraulic entrainment air pump, which was designed and developed at about the start of the war in Europe in 1914. When this pump was about to be adopted, it became apparent to Mr. Wheeler that it was necessary to simplify the air pump problem of a power plant by a steam ejector type of air pump. All entrainment pumps had shown the necessity of an improved method of removing air from a condenser. An opportunity occurred again and he was able to guide the development of the successful steam air ejector in American power plants. These are but a few of the ways in which he has contributed to better power plant operation.

In all business associations, Mr. Wheeler has had the affection and esteem of his employes. His only differences with his co-directors or partners have resulted from his continuous efforts for advancement of methods and design, his endeavor to stand high in the particular branch of business with which he specialized.

For his associates he has always had available loyal men who have found by close association with him that he appreciates their efforts, rewards them and encourages to further advances.

He has raised a family of seven children; is a devotee of golf, which he says has aided him in maintaining his health and vigor, and helps him to keep up the strenuous pace in business that he has maintained for over 47 yr.

Mr. Wheeler is a member of the A. S. M. E., merchants' Association, Machinery Club, Manufacturers' Club, Seaview Golf Club, Whitemarsh Valley Country Club, Royal Societies Club and others. He is a director in several industrial concerns, one national bank and two insurance companies.

Power Generated by Public Utilities

THE ACCOMPANYING tables, recently compiled by the United States Geological Survey, compare the production of electric power and consumption of fuel by public utility power plants in the various

TABLE I. ELECTRIC POWER PRODUCED BY WATER POWER AND FUELS IN PUBLIC UTILITY PLANTS

State	Thousands of kilowatt-hours produced							
	By water power				By fuels			
	February	March	April	July	February	March	April	July
Alabama	29,541	30,878	28,662	28,442	11,089	4,907	4,477	5,689
Arizona	5,967	6,469	7,077	7,478	17,440	21,807	16,488	18,677
Arkansas	79	79	89	88	6,268	6,625	6,230	7,698
California	187,486	215,914	220,776	200,599	38,198	33,276	34,886	116,804
Colorado	13,141	14,354	15,019	14,947	17,379	17,144	14,325	13,177
Connecticut	7,043	14,864	15,804	8,941	49,269	47,409	51,355	68,188
Delaware	0	0	0	0	5,551	4,764	4,658	5,282
District of Columbia	0	0	0	0	16,094	19,511	16,497	19,521
Florida	670	693	777	944	6,865	6,759	7,774	6,791
Georgia	25,209	27,894	21,404	24,234	6,054	6,063	6,200	6,595
Idaho	41,450	39,915	35,019	30,302	158	257	178	1,510
Illinois	15,211	15,283	16,134	15,523	198,899	207,873	194,109	163,518
Indiana	3,998	3,954	3,811	3,736	65,542	64,617	61,980	64,554
Iowa	44,182	46,296	46,737	51,923	33,993	34,924	33,644	34,531
Kansas	1,267	1,235	913	961	29,619	30,458	40,870	36,093
Kentucky	4	4	4	4	16,746	19,187	18,558	19,906
Louisiana	0	0	0	0	14,150	14,476	14,562	15,516
Maine	18,851	20,157	18,708	17,978	73	78	82	320
Maryland	264	271	256	229	10,435	13,898	11,442	16,978
Massachusetts	18,698	21,265	18,528	16,169	101,799	100,080	90,601	110,467
Michigan	52,834	59,940	62,211	50,044	97,280	96,125	88,562	108,402
Minnesota	18,303	20,740	23,304	37,456	6,116	10,280	7,361	10,329
Mississippi	0	0	0	0	3,115	3,295	4,927	5,306
Missouri	4,297	5,280	4,418	3,237	37,307	40,561	36,546	39,152
Montana	68,408	77,288	77,865	63,280	893	898	821	848
Nebraska	1,454	1,558	1,116	1,308	16,493	16,413	16,004	16,902
Nevada	3,196	3,818	3,470	3,569	137	121	727	780
New Hampshire	4,946	5,763	5,823	4,499	3,309	3,114	1,898	3,814
New Jersey	1,085	197	187	161	75,862	76,413	76,562	79,546
New Mexico	57	56	80	144	1,416	1,556	1,480	1,603
New York	135,219	221,078	220,677	212,034	266,371	266,537	270,044	276,528
North Carolina	42,646	42,218	40,758	42,217	7,149	7,466	7,088	9,243
North Dakota	0	0	0	0	2,218	2,400	2,108	2,449
Ohio	5,263	5,252	4,566	2,870	189,041	184,287	183,703	208,840
Oklahoma	167	185	149	161	13,090	13,786	12,969	13,226
Oregon	27,876	29,115	27,248	29,180	4,784	3,769	3,539	4,323
Pennsylvania	50,025	62,803	56,466	53,649	280,970	296,980	280,097	326,021
Rhode Island	563	1,043	726	240	32,767	31,405	26,839	19,881
South Carolina	43,899	43,864	43,227	42,649	9,269	4,010	5,078	5,450
South Dakota	2,623	3,078	3,104	3,448	1,940	1,980	1,980	2,250
Tennessee	45,640	45,223	37,999	35,316	9,774	10,680	10,408	9,154
Texas	208	264	228	191	43,078	47,616	44,918	46,817
Utah	13,135	15,403	17,434	18,405	0	0	0	0
Vermont	15,428	16,674	19,468	11,748	173	179	187	976
Virginia	17,683	20,192	18,256	17,865	17,884	19,709	16,538	19,886
Washington	70,779	79,346	74,976	79,981	4,171	4,681	4,164	5,434
West Virginia	1,979	1,845	1,642	1,998	58,690	58,108	52,914	64,021
Wisconsin	33,554	47,831	46,893	41,513	33,916	35,075	29,288	27,037
Wyoming	248	172	126	179	3,313	3,603	3,249	3,386
Total	1,148,634	1,308,328	1,304,073	1,213,729	1,834,223	1,841,643	1,717,583	1,928,617
Total, by water power and fuels					2,982,856	3,149,971	3,021,656	3,142,346

Average daily output in kilowatt-hours: February, 106,551,000; March, 101,609,000; April, 100,870,000; and July, 101,368,000.
Percentage of total output produced by water power: February, 38; March, 41; April 43; and July, 39.

TABLE II. FUELS USED BY PUBLIC UTILITIES IN PRODUCTION OF POWER

State	Coal, Short tons				Petroleum & Derivatives, Barrels				Natural Gas, Thousands of cubic feet			
	February	March	April	July	February	March	April	July	February	March	April	July
Alabama	27,026	16,467	14,836	15,458	8	8	8	8	0	0	0	0
Arizona	6,316	6,160	5,360	7,316	124,520	88,011	65,824	61,030	0	0	0	0
Arkansas	13,386	11,177	9,902	8,564	447	489	456	450	63,430	85,398	97,726	182,846
California	0	0	0	0	199,388	185,127	161,651	550,999	21,611	181,765	375,643	242,238
Colorado	41,507	44,079	36,135	37,888	100	95	98	174	0	0	0	0
Connecticut	63,942	62,234	58,094	67,513	333	323	279	213	20,766a	12,615a	11,309a	0
Delaware	8,610	7,713	7,000	6,604	0	17	0	0	0	0	0	0
District of Columbia	21,418	21,440	20,983	21,412	0	0	0	0	0	0	0	0
Florida	3,424	5,594	3,066	3,193	32,714	32,085	28,785	30,745	98	151	3,780	0
Georgia	16,589	11,934	12,009	13,560	130	130	167	2,386	0	0	0	0
Idaho	120	111	121	88	10	10	10	9	0	0	0	0
Illinois	336,309	350,824	318,378	304,160	3,918	3,198	2,142	984	0	0	0	0
Indiana	141,060	157,931	143,829	142,587	448	167	420	402	2,159	2,108	1,909	1,878
Iowa	86,746	79,694	72,211	69,703	787	730	743	720	0	0	0	0
Kansas	47,588	51,022	48,636	50,817	47,747	60,803	58,432	60,742	83,405	86,901	65,374	80,846
Kentucky	36,252	39,386	37,360	39,390	358	351	353	341	0	0	0	0
Louisiana	14,305	15,885	13,878	11,324	30,811	30,094	28,192	30,508	55,092	47,458	49,599	63,624
Maine	383	348	367	534	7	7	17	0	0	0	0	0
Maryland	28,452	23,657	20,755	25,961	19	18	30	30	1,600	1,600	1,600	1,360
Massachusetts	139,171	143,525	139,877	130,606	24	14	17	21	0	0	0	0
Michigan	129,417	124,941	113,623	129,613	191	104	139	204	0	0	0	0
Minnesota	67,282	39,810	25,038	25,866	1,138	1,016	854	832	0	0	0	0
Mississippi	16,381	16,542	16,008	13,272	370	330	311	443	0	0	0	0
Missouri	86,648	89,531	82,143	82,004	33,671	21,053	19,519	18,847	0	0	0	0
Montana	5,537	5,591	5,455	4,894	530	492	488	502	1,008	960	907	913
Nebraska	29,946	30,966	29,813	31,904	3,612	3,509	3,433	3,367	0	0	0	0
Nevada	198	180	140	195	900	1,044	997	1,780	0	0	0	0
New Hampshire	5,395	3,911	3,241	5,808	20	20	3	3	0	0	0	0
New Jersey	112,366	115,711	114,137	116,944	92	103	80	79	0	0	0	0
New Mexico	4,045	4,438	3,627	4,153	1,060	1,360	1,378	1,610	0	0	0	0
New York	366,565	363,538	325,474	336,004	544	546	501	1,224	149,831	164,408	147,432	56,949
North Carolina	15,648	16,234	15,613	14,915	20	20	20	20	0	0	0	0
North Dakota	16,638	17,153	14,473	14,808	539	514	530	553	0	0	0	0
Ohio	314,873	321,643	289,610	283,658	739	842	764	689	350,488	323,320	333,684	512,586b
Oklahoma	11,136	12,578	10,076	8,717	8,109	6,300	9,921	20,067	425,813	477,080	458,496	474,930
Oregon	223	455	223	233	27,684	19,459	15,456	6,664	0	0	0	0
Pennsylvania	401,874	412,561	396,098	388,357	32	14	16	297	43,301	54,450	55,533	40,531
Rhode Island	29,692	22,034	20,819	22,648	0	0	0	0	0	0	0	0
South Carolina	9,844	9,540	8,811	8,881	78	82	93	102	0	0	0	0
South Dakota	7,082	8,396	4,371	6,841	3,164	3,379	3,091	3,193	0	0	0	0
Tennessee	23,726	28,724	24,710	23,156	86	84	81	82	0	0	0	0
Texas	25,330	33,963	26,618	29,269	170,905	181,397	178,033	188,691	175,695	179,760	177,778	114,148
Utah	65	61	31	0	0	0	0	0	0	0	0	0
Vermont	542	412	246	3,909	2	2	2	2	0	0	0	0
Virginia	29,127	31,444	28,453	30,674	122	153	53	122	0	0	0	0
Washington	3,611	5,473	2,411	2,060	17,810	18,804	17,879	22,071	0	0	0	0
West Virginia	62,459	70,717	62,426	63,556	52	58	52	45	118,029	142,688	180,069	264,054
Wisconsin	69,235	74,987	55,037	46,221	644	662	565	574	0	0	0	0
Wyoming	12,450	15,364	12,242	12,752	8,470	9,062	8,840	4,008	5,278	6,808	3,129	3,481
Total	2,873,265	2,919,406	2,648,760	2,676,688	722,133	671,006	610,736	1,014,653	1,413,504	1766,850	1,859,667	2,040,565

a Artificial gas.
b Includes 182,415 artificial gas.

states for the months of February, March, April and July, 1919. It is interesting to note that practically 40 per cent of all power developed for public use comes from hydroelectric plants. Without question, this percentage will be increased as the result of the passing by Congress of a water power bill designed to stimulate development of our natural water-power sites.

These figures do not, however, include industrial plants, which more than likely would bring the percentage of hydroelectric power down, as the principal developments are for public utility service.

The comparative importance of coal, fuel oil and gas as fuel for power plants is well illustrated in the second table, which also indicates the localities in which the different fuels are used most extensively; presumably the most economical fuel is used.

These reports are based on returns received from about 3000 electric power plants engaged in public service, including central stations, electric railways, and certain other plants which contribute to the public supply. Returns were received from plants whose aggregate capacity of generators is about 90 per cent of the total installed capacity of generators of public utility plants. Estimates of the output of plants which did not submit returns were made from available information. The figures given are subject to revision in subsequent statistical reports of the United States Geological Survey relating to power production.

Vertical Hydroelectric Thrust Bearings

DESCRIPTION OF THE FOUR MOST COMMON TYPES, AND NOTES ON THEIR CARE. BY L. W. WYSS

EFFICIENT single runner vertical hydroelectric units could not have gained their prominence in the last few years without the development of reliable thrust bearings. The success of these bearings depends upon the attention given them during operation as well as during erection, and in view of this fact it is well for the hydroelectric operator to familiarize himself with the different types.

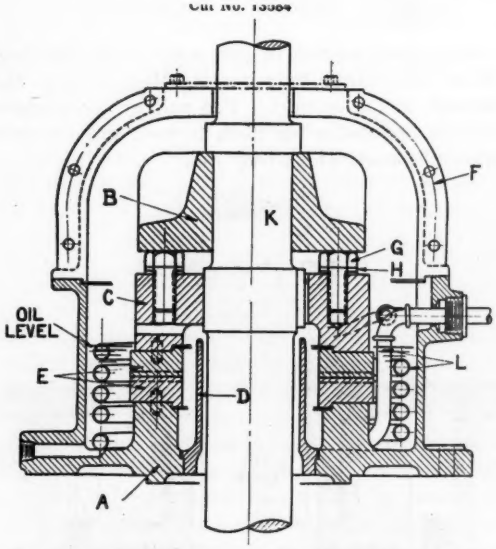


FIG. 1. SECTION THROUGH CAST-IRON THRUST BEARING. A—HOUSING, B—SPLIT RING, C—THRUST COLLAR, D—OIL RETAINER, E—THRUST PLATE, F—HOUSING COVER, G—ADJUSTING SCREWS, H—ADJUSTING SHIMS, K—SHAFT, L—WATER COOLING COILS

Thrust bearings run in a bath of oil at all times and in the past it has been customary to circulate this oil through cooling coils to remove the heat as fast as it is generated in the bearings. In this case, gear- or belt-driven pumps are used for individual circulation, or the oil may be pumped through a central oiling and filtering system. When the oiling systems for the thrust and guide bearings are separate, operators may be inclined to underestimate the importance of continual circulation in the guide bearings, attaching more importance to the thrust bearing circulation; however, an interruption to circulation of oil in guide bearings will result in serious trouble, as the bearing will soon heat and wipe the babbit, while, on the other hand, the thrust bearing will only heat slowly when the oil does not circulate. Instead of circulating the oil for thrust bearings, water cooling coils placed in the thrust bearing housing are gaining in favor, as this is the cheaper and simpler way to remove the heat of friction from the oil. Some thrust bearings are located under the generator,

FIG. 2. VIEW OF BEARING AND HOUSING IN FIG. 1 SHOWING THRUST PLATES

but it is now agreed that the proper place for them is on top of the generator.

The following paragraphs describe the four principal types of thrust bearings supplied by American manufacturers.

The bearing shown in Fig. 1 has no babbited running surface, as both the revolving and stationary thrust plates are made of a special close grained iron, the surfaces of which are carefully machined and scraped. Adjusting shims, H, are provided under the adjusting screws, G, for alinement. These shims are U-shaped washers which are tightly clamped under the heads of

the screws so that the screw threads carry none of the rotor weight. There are grooves in the thrust bearing plates so that a continual supply of oil will reach the bearing surfaces. Water for the cooling coils is usually obtained from the reservoir at hydroelectric stations. Figure 2 shows the housing and thrust plates as located on top of the generator.

The bearing shown in Fig. 3 consists of about four, six or eight segmental babbited bearings upon which the thrust collar runs. Each of these bearing shoes has a single pivot support located toward one end of the shoe

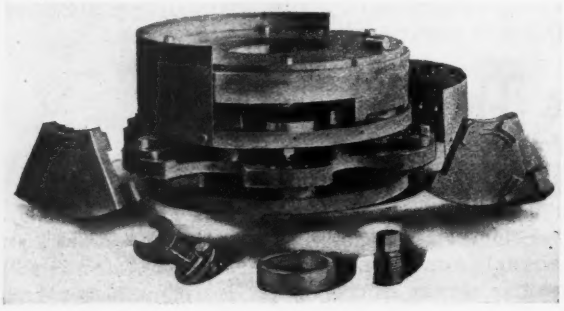


FIG. 3. THRUST BEARING WITH THRUST PLATE RUNNING ON BABBITED SHOES

slightly beyond the center of gravity in the direction of rotation. This arrangement allows a wedge-shaped film of oil to form between the shoes and thrust collar.

Figure 3 shows this type of bearing provided with jack screws to adjust the individual shoes to carry their proportional part of the weight. Lock wrenches are provided to make sure that the jack screws do not turn.

Sometimes this type of bearing has no adjustments for the shoes, complete confidence being placed in accurate machine work and erecting. Frequently a leveling

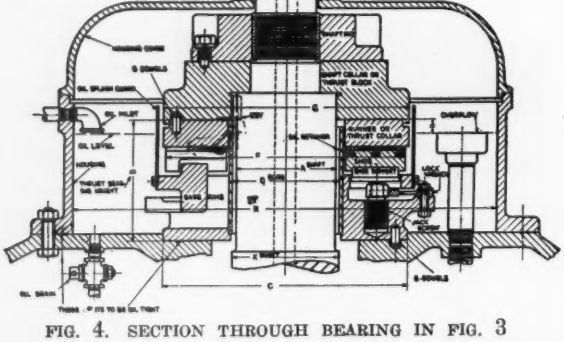


FIG. 4. SECTION THROUGH BEARING IN FIG. 3

washer is used upon which the shoes rest, and which compensates for any slight misalinement of the shaft. Still other types have their shoes adjusted by wedges. Figure 4 shows a section of the bearing illustrated in Fig. 3.

Figure 5 shows a spring thrust bearing. The cast-iron rotating ring runs on a babbited ring supported by a great many short helical springs. A distinctive feature of this thrust bearing is that it will automatically adjust itself while in operation if there is a loss of alinement due to the settling of the foundation or other causes.

Figure 6 shows a cross section of a combined thrust and guide bearing. The bearing has water cooling coils. Grooves in the bearing rings supply fresh oil during operation.

Figure 7 shows a broken away view of a combination roller thrust and guide bearing. The roller bearings

FIG. 5. SPRING THRUST BEARING

rest on self alined washers to assure an evenly distributed load on all the rollers by adjusting them to any slight inaccuracies in its support. The rollers are staggered so that it is impossible for them to wear grooves in the steel plates between which they roll.

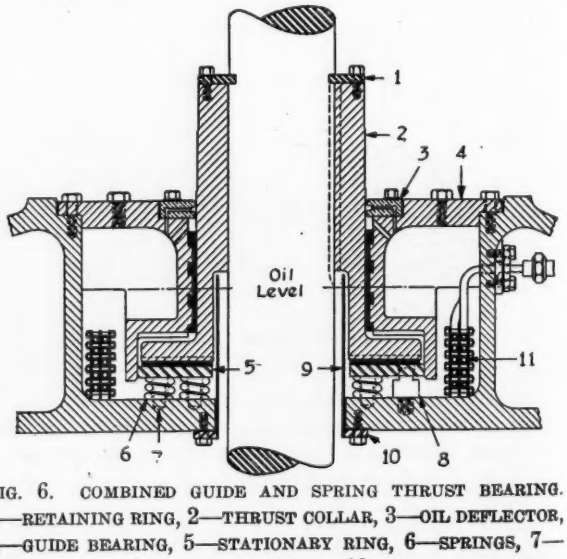


FIG. 6. COMBINED GUIDE AND SPRING THRUST BEARING. 1—RETAINING RING, 2—THRUST COLLAR, 3—OIL DEFLECTOR, 4—GUIDE BEARING, 5—STATIONARY RING, 6—SPRINGS, 7—DOWELL PIN, 8—OIL WELL TUBE, 10—SUPPORTING RING FOR OIL WELL TUBE, 11—COOLING COILS

Instances have been known where a general feeling of uneasiness existed among the crews of hydroelectric plants because the thrust bearings were running rather warm. This is to be expected with some thrust bearings and no alarm should be felt, unless the temperature has

increased higher than it was accustomed to be under the same conditions of room temperature, effective head of turbine, amount and temperature of circulating water.

Thrust bearings often squeak just at starting; this is to be expected, as the oil film has not formed between the bearing plates as yet. Vertical machines should not be allowed to run at extremely low speeds for any length of time, as the oil film may be so thin that certain points of the bearing may rub, causing the babbit to wipe. As

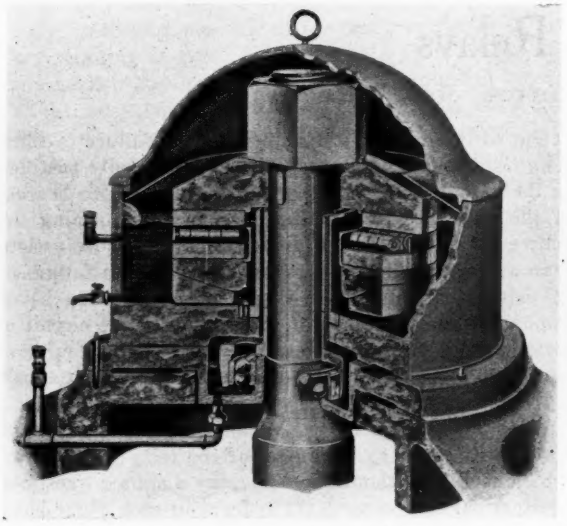


FIG. 7. VIEW OF ROLLER THRUST BEARING BROKEN OPEN TO SHOW DETAILS OF CONSTRUCTION

a general rule, vertical machines should be started and stopped without delay. To stop them quickly, the field switch may be left closed until the machine comes to rest. Some generators have air brakes for this purpose.

Injector Trouble

By H. W. Rose

IN discovering the cause of the various difficulties under which an injector may be laboring, we had better start at the foundation and check every detail and see whether it is correct.

For instance, when an injector fails to get the water there are several causes which must be thoroughly investigated before proceeding further in search of the trouble. The supply may be cut off; i. e., no water at the source; strained, clogged suction pipe hose or valve stopped up; if a hose is used, its lining may be loose, which will frequently cause the trouble. After thoroughly convincing yourself that thus far that portion is as it should be, proceed to the next step.

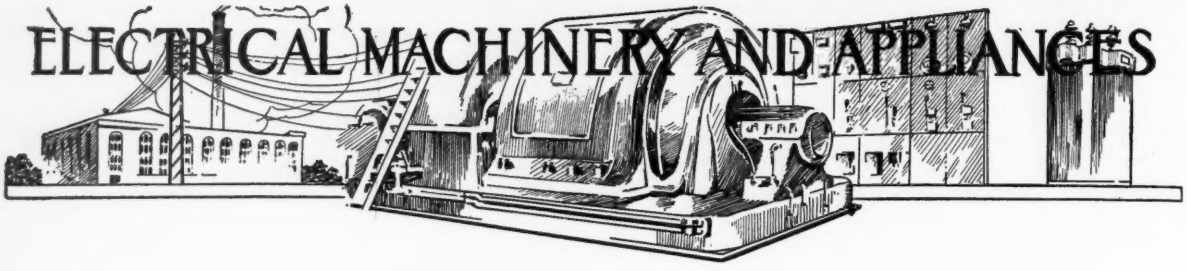
A large leak may be in the suction line; but carefully note that a small leak will not prevent the injector from getting its water, but will cause it not to work. The water may also be too hot, and in some cases the injector may become overheated from trying to get it in operation. After several attempts have been made, should it fail to work, it should be cooled by pouring several buckets of cold water over it or by turning a cold water hose on it. Next examine the water at the supply source and ascertain whether or not it is above the normal temperature of the surrounding atmosphere; if so, it is not a good working temperature for the water to be used in an injector. I admit, however, there are numerous cases where injectors are working successfully under much more severe condition.

A good scheme sometimes practiced in trying to start a heated injector is to open the drain cock, turn steam on slowly and shut it off quickly, which will cause cold air to rush into the suction pipe and cool it off; this method, if not successful upon its first trial, will sometimes succeed after one or two attempts.

Lack of steam pressure for the lift of water is often found to be the cause of much trouble. Sometimes it is the reverse—too much steam pressure, which trouble has to be determined and corrected by the operator. In a number of cases it is found that the injector will get the water but will not force it into the boiler. A few general causes of that feature of injector trouble are: The lack of a globe valve on the suction line to regulate the water, or the supply water not properly regulated; dirt in delivery tube; faulty check valve; obstruction between injector and check valve, or between check valve and boiler. Sometimes a leak in the suction pipe admits air to the injector along with the supply water, through one of the connections right at the injector, between the piping and the injector.

In connecting up an injector, connect the steam pipe directly into the boiler steam drum, and at a spot where the dry steam is obtainable, and have no other connections whatever attached to that line. The suction pipe should have as few bends, crooks, tees, els and forty-fives in it as possible, as they all produce a friction which throws unnecessary work upon the injector, and always, if possible, have the suction line the same size as the connection allowed for it at the injector, and if you want to make a first-class job of it, have the pipe from the beginning of the suction line up to the injector one size larger than the injector itself calls for, and follow the same instructions in the discharge line from the injector to the boiler by including a globe valve near the boiler, and afterward a check valve. The globe valve is not only serviceable for shutting the water off the boiler, but it is also indispensable, owing to the fact that if the check valve should give you trouble, you can thereby shut the boiler off from the check valve, allowing you a convenient way of overhauling the check valve without having to cool the boiler down. Another important feature in installing the injector is not to get it too close to the boiler, as the heat from the boiler will cause an injector to work improperly at times. A distance of 12 in. from the boiler is found to work quite satisfactorily. One of the most serious troubles is found where the injector has been placed too high. In installing the injector, if possible, see that the water enters at the lowest point possible in the boiler and also have the injector itself about a foot below the center line of the boiler.

A Pennsylvania boy of 12 shot himself to avoid going to school. Many another boy lives on merely to make suicide on that account unnecessary for his son, by sending the child to work at the age of 12 to help support the family which he, the uneducated father, is unable to do.



Protective Relays

THEIR CARE AND METHODS OF TESTING. BY J. T. KANE

THE protective relay which actuates the automatic circuit breaker is really an important piece of apparatus in the power plant; yet, because it is so inconspicuous a part of the equipment, it is apt to escape the care it needs. It is so delicate a device as to require the closest attention; a film of dust on its contacts, a loose or broken control wire, a sluggish operating mechanism—so many things can and actually do happen to make it inoperative. It is in front rank in importance as a part of the plant equipment because so much hinges on its successful functioning; the failure of a feeder, or a piece of apparatus, which would amount to nothing more than the original failure if the affected circuit were properly isolated from the rest of the system, might develop into an extensive accident should one or more of the relays in that circuit fail to operate.

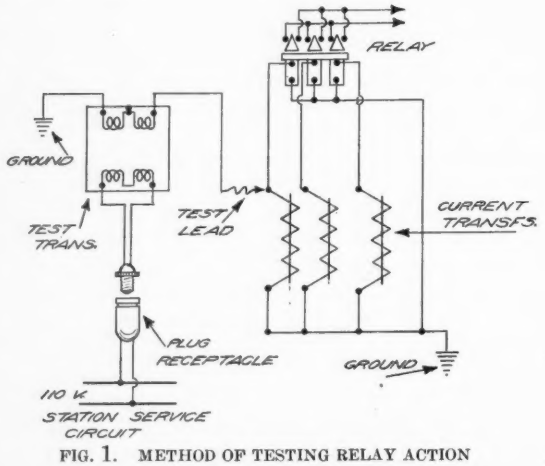


FIG. 1. METHOD OF TESTING RELAY ACTION

The big central station systems appreciate both the value of the relay and the potential danger of it on its failing to operate, and in all of them elaborate provisions are made not only for the care of the relay, but for the periodic testing of it and the circuit-breaker it operates, as well. Experience has taught that once yearly is not too often to calibrate the relay and check its setting; furthermore, that this annual calibration should be re-enforced by more frequent tests to determine its operating condition, such as by monthly tests in plants of small capacity and simple circuits, and weekly or bi-weekly tests in plants of great capacity and complex circuits. While such close attention is a necessity with the generating station relay because of the extent of the damage attendant upon its failure to function, the expense of such special care is hardly justified in the case of the relay in the substation where because of the reactance of the transmission lines forming the source of supply there ordinarily nothing more serious than an interruption to service accompanies a failure of the equipment, unless, of course, that substation be an important one by reason of its location in the circuit as a tie-in point between generating stations or a source of supply to other substations or because of its great capacity or proximity to the generating station.

The fine points of the manner of calibrating and testing the relay, and the part of the relay circuit from which such tests should be made, are disputed questions. Custom varies, the methods in force in each plant being the outcome of the experience of that plant. It has been authoritatively claimed that the secondary winding of the current transformer should be included in the testing circuit when the relay fed from it is being calibrated; though satisfactory results are obtained by calibrating directly from the relay coil without including the remainder of the relay-current transformer circuit. The best point from which to test the action of the relay is not from its closing, or circuit-breaker control contacts, as the following incident will prove; the test should cause the relay itself to operate and, if possible, take in the entire circuit from the current transformer.

On an electrical system of 200,000-kw. capacity, the line fuse boxes on a 2200-v. distribution circuit failed on the terminal pole close to the substation, burnt down the three conductors of an 11,000-v. supply feeder, damaged several oil-circuit-breakers in the substation and entirely shut that station down. The generating station reported a system disturbance during which a supply feeder to another substation automatically tripped itself out, and the damaged feeder was tripped out by the operator. The first feeder after being tested was restored to service, and the mystery of its strange interruption coincidental with the breakdown at a distant part of the system, was not explained until after the linemen sent to repair the 2200-v. circuit had reported the 11,000-v. lines down at that point and investigation in the generating station disclosed the fact that the relay of the feeder that was needlessly interrupted was connected to the current transformers of the feeder that had been burned down on the pole.

On that system now, all relays are operated from the terminals of their current transformers once a month, and from the terminals of their operating coils once

every week or two, depending upon the rush of work in hand. In each test, the relay is operated from each phase in succession, and each time is permitted to trip the circuit-breaker controlled from it. The tests are made by means of a small testing transformer. The primary of this transformer is fed from the 110-v. station service lines through the regular extension-cord plug receptacles located about the plant. Its secondary has two taps, one for 10 v. and the other for 20 v., for regulating the amount of current taken from it. One side of all instrument wiring in the station is grounded. Similarly, in testing, one side of the test transformer secondary winding is grounded, and the lead from the other side of it is applied directly to the ungrounded terminal of the relay current coil or to the terminal of the current transformer winding connecting to the relay. When testing from it, the current transformer is not disconnected from the relay circuit; its secondary winding is

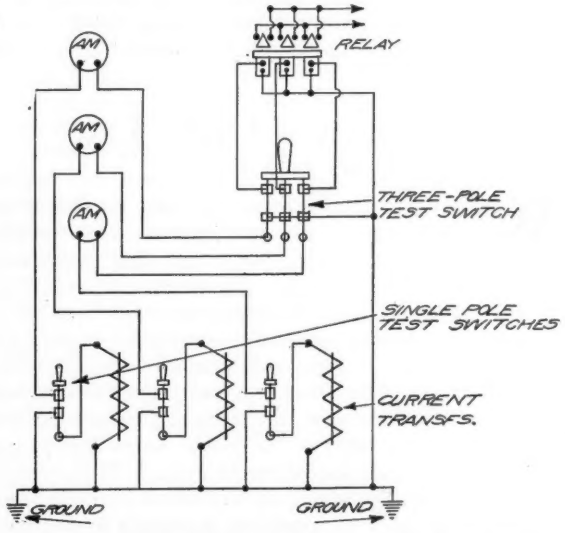


FIG. 2. CONNECTIONS OF TEST CUTOUT SWITCHES

let form a shunt path in the testing circuit, as shown in Fig. 2, to conserve the time that otherwise would be required to disconnect and reconnect it.

Previously in that station the relays had been tried regularly every week by closing their control contacts by hand, thus causing their circuit-breakers to be tripped out; but the uselessness of such a test became apparent after the accident mentioned had occurred, and still later, a relay was apprehended that had its operating coil completely grounded out.

It is customary to connect the relay in the same circuit with the ammeter, where more than one set of current transformers are required, so as to have an immediate indication of a break in this circuit; however, as the ammeter is usually connected ahead of the relay, a ground in the relay winding or on the circuit beyond the ammeter would be evident only in whatever abnormal ammeter registration resulted from the change in impedance of the circuit, and since this reading might be caused by unusual loading conditions on the primary apparatus, it doubtless would escape further investigation.

The calibration of the relay, which should be done at least annually, may be accomplished directly at the terminal block or cutout switch of the relay current coil, since the impedance of the current transformer secondary winding is designedly meager and in the complete circuit to the relay is negligible. For the period of the work of calibration on the relay, the current transformer may be short-circuited, the relay disconnected, and the primary apparatus protected by the relay continued in service. It is a safer practice to take the primary apparatus out of service during the test than to allow it to operate without relay protection; at least in the case of generating station equipment, because of the large capacity on the bus there. Such precautions are not so essential at the substation end of transmission lines, or at the load end of other circuits having relay protection on their source end, particularly so where withdrawal of the apparatus from service could be effected only at off-load periods, and the testing of its relays then would entail the extra expense of Sunday or night work.

The installation of test cutout switches of the double-throw, short-circuiting type, in which the second contact is made before the first is broken, will simplify and expedite both the testing of relays and the locating of faults on the current transformer secondary circuits. A single-pole switch of this type, installed in the same cell with it and close to the current transformer, and a three- or four-pole switch of the same type, depending upon the number of phases of the relay, located directly at the relay, both prove capital investments for the facility they afford in the execution of the various work done on the switchboard apparatus. The latter switch is the more indispensable of the two. The connections of these switches are shown in Fig. 2.

Synchroscope Fault Ascribed to Generator

IN ONE of our plants where two synchroscopes were provided, with a double-throw switch for selecting either instrument, the men always chose the synchroscope nearest to the panel of the generator they were synchronizing.

For some time it had been noticed that one of the generators, a 10,000-kw. unit, always emitted a savage grunt when its switch was closed, no matter how carefully the synchronizing was done; and it was concluded that the generator had some peculiar characteristic of design that was responsible for the disturbance caused whenever it was paralleled with other units.

One day an operator synchronized this generator from the synchroscope at the opposite end of the switchboard, and the unit went on the line satisfactorily. The synchroscopes were then checked against each other, and the one which had always been used with this particular generator was found to be over 15 deg. slow. The set-screw holding the pointer on the shaft had loosened and allowed the pointer to be twisted out of place by the jerks, or "kicks," produced in the instrument at the instant of synchronizing. Much hard usage of the generator could have been prevented had we thought to alternate the synchroscopes or to check them against each other.

Service Meter Troubles

By W. A. Darter

SOURCES of meter trouble affecting registration of watthour meters are becoming more prominent, due to their increasing use and more complex service systems.

A general source of meter trouble is that due to carelessness of the meter man when the meter is installed. Sometimes the service wires are connected into the wrong side of the meter, causing reverse registration. Some meters require the cover removed before they can be connected, and in this case dirt or loose particles are likely to get on the rotor and interfere with its running. Especially is this true if the meter has been in service for some time and the cover is removed. The lower jewel, also, is sometimes left out of place and the meter does not register from the beginning. Sometimes small ants will find their way into the meter and stop it, or a small spider might be closed up in it and proceed to spin his web about the rotor. To guard against a meter not registering correctly after it is put into service, the meter man should test the meter, either by timing the rotation of the rotor against its load, or by an instrument. If

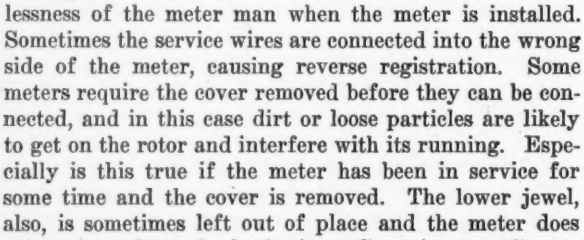


FIG. 1. WITH TWO GROUNDS EXISTING, AS SHOWN HERE, SHUNTING OF THE METER WILL RESULT

FIG. 2. GROUNDS WHICH MAY CAUSE CONSIDERABLE METER TROUBLE

possible, the meter should be calibrated after it is put into service in order to make sure the accuracy of the meter has not been impaired while handling.

If the meter does not register after it is put into service, the trouble, if not caught then, will not be discovered until the meter reader reads the meter. This condition is embarrassing to the company, because the company has no basis upon which to make a charge; and usually the charge is postponed until a reading can be had upon which a charge can be made. If the meter is running slow, due to dirt on the rotor or bad setting of the jewel, the registration will be only a part of the energy used, but it may be enough to mislead the company and the company will lose until the meter either stops or is tested. The meter, if connected into service backward, will register in the negative direction the same amount as it will register in the correct position.

Some power companies make it a practice to ground one side of the secondary system, and in nearly every case ground the neutral wire on a 110-220-v., three-wire system. If the current coil of a meter happens to be connected to the grounded secondary, then a ground inside the meter, on the grounded side, will shunt the current around the current coil of the meter. The value of flow of this depends upon the conductivity of the two parallel circuits, and is in the same ratio as their conductivity. Also, if fuse Fa is blown or withdrawn, as shown in Fig. 2, all the current will be bypassed and the meter will revolve backward. This is due to the electrical energy consumed by the shunt coil of the meter passing through the current coil in the reverse direction as shown.

When the secondary system is not grounded, two grounds may come into existence at two different points on the same secondary, as shown in Fig. 1.

If A and B have grounds on the inside of their meter connections, then part of the current used by A will take the ground circuit through B's wiring. If fuse Fa is withdrawn or blown out, then all the current A uses will pass through fuse Fb; and if fuse Fb is not large enough to carry both loads, will blow. This condition will cause B to complain and the trouble will be found. If the two grounds happen to be on the current coils of the two meters, as shown in Fig. 2, then all the current shunted around A's meter will be registered through C's meter, making C's apparent consumption in excess of what it should be.

Central station companies are beginning to do away with grounds on their secondary systems wherever it is possible to do so. Every meter placed in service should be inspected every few years and tested for accuracy if necessary.

Simplicity of Ohm's Law

By J. B. Dillon

WHILE it may seem queer to some, yet it is a fact that many people are puzzled to remember Ohm's Law. To those who find trouble in recalling that:

$$\text{Current} = \frac{\text{Electromotive force}}{\text{Resistance}}$$

it has been suggested that they carry the formula, with its various ramifications, in a pocket memorandum book; but, to this they reply: "A fellow cannot always have the book just when and where he needs it."

To overcome their failure to recall the formula, some hit upon the plan of punching it upon a pocket piece, about the size of a silver quarter.

I read of another case where somebody suggested that the word "Erie" be thought of, thus we would have "E" for e.m.f., on top, "R" our divisor, directly below, and "I" as the quotient, for our answer.

In my early days I felt there was some sort of bugbear attached to Ohm's Law, but a simple plan hit upon to dispel such fear was to think of it in figures and not letters. The figures selected were:

$$5 = \frac{10}{2}$$

Once that was done I had no further trouble. I knew that the electromotive force was "high," the other quantities "I" and "R" when multiplied together would equal the high; therefore, I had only to remember the number 10, using it as my "beacon light," regardless of any problem falling within the three cases of the law, the rest being merely a matter of figuring it.

There is nothing mystifying or difficult about either method. Use the one that you prefer, but do not stop until you have the three cases of Ohm's Law so well understood that you can recall them at any moment as you do your multiplication and division.

Physical Examination of Hoisting Engineers in Utah

By C. A. Allen and Dr. A. L. Murray

IN THE spring of 1919 the Industrial Commission of Utah undertook the assembling of safety orders covering metal mining operations. Just at that time there appeared several articles in the mining papers advocating the licensing of hoisting engineers, so this subject was given careful consideration.

The licensing of hoisting engineers means that they must pass an examination covering the mechanical features of hoists and boilers, and must have a certain amount of experience. This undoubtedly serves to get a class of hoisting engineers that are better informed about the mechanical operation and theoretical considerations in hoisting and the only room for argument against it is that it is difficult to give an examination that will determine whether or not a man is a competent hoisting engineer. A man might pass an excellent examination yet be absolutely unqualified to operate a hoist and the judgment of the mine superintendent would have to be depended upon to choose the right man from among those who were licensed. This difficulty of properly determining, by ordinary examination, a man's qualifications to run a hoist caused the idea of licensing in the ordinary sense of the word to be abandoned; but, as there was no question that a hoisting engineer should be physically fit, it was decided to require a medical examination, and at the same time to require the hoisting engineer to state his experience, so the state would have a better knowledge of his general qualifications.

The orders covering the question were therefore issued as follows:

Hoisting Engineer

Section 23. (a) Hoisting engineers shall be appointed by the superintendent, or by the master mechanic with his approval. They shall be men familiar with the details and working of hoisting engines, shall be able to read and write English and not less than 18 yr. of age.

(b) Hoisting engineers, who hoist men, shall be not less than 21 yr. of age, and, before being allowed to operate a hoist on which 10 or more men are handled daily, the hoist engineer must be examined by and present a certificate of health from a reputable doctor known to be such by the superintendent. This certificate of health must be on a form prescribed by the commission and must show the health of said hoisting engineer to be such that there is no danger of his becoming physically or mentally incapacitated while performing his duties or under the stress of excitement.

(c) All engineers now operating hoists, which handle 10 or more men daily, shall at once be examined and obtain such certificate in like manner and all hoisting engineers shall hereafter be examined in like manner at least once every year.

(d) It shall be the duty of the superintendent to permit no other than such duly appointing hoisting engineers to run such engine or hoisting machinery; except that, by and with the consent of the superintendent, specified apprentices may be taught the operation of the hoisting engine at such times and under such restrictions as the superintendent may determine to be free of risk to life and limb. Any superintendent failing to make such appointment of hoisting engineer, or knowingly appointing any hoisting engineer not qualified as above, shall be guilty of a violation of these orders.

(e) At every shaft in which 50 or more men are hoisted or lowered on any shaft, the commission may require that there be with the hoisting engineer, when the shift is being hoisted or lowered, an extra man sufficiently competent to operate the engine in case of an emergency.

It should be stated that previous to issuance, the orders were submitted to a committee of representative mine operators and mine employes and there were no objections raised except to the last paragraph. This paragraph originally made it compulsory to have another man beside the hoisting engineer when the shift was being handled at the larger mines. The operators felt that this would not be necessary in all cases, so it was changed to be optional with the Industrial Commission as to whether it shall be required or not. The reason for exempting men handling less than 10 men was largely one of expediency; but it was also felt that at small properties where few men are working, the hoist is usually of slow speed and the engineer is under no particular strain.

After the orders were made effective by the Industrial Commission, a form for examination was issued which is too detailed to reproduce here. In drafting this certificate, two objects were considered: First, whether the applicant is mentally qualified and second, whether on physical examination the condition of the applicant is such as to demonstrate his physical fitness for the work required of him.

Under mental qualification, the ability of a hoisting engineer to read and write English is practically the only requirement. He must be familiar with the safety orders of the commission and of course must be able properly to interpret signals and rules which demand a knowledge of English. His other mental qualifications are vitally important, but they can best be judged by the mine superintendent or master mechanic who is acquainted with him. As regards experience, that is left also to the mine superintendent, although any man who did not show a reasonable amount of experience, depending upon the size of hoist he is to operate, would be investigated by the Industrial Commission.

Under physical fitness, a hoisting engineer should be of good health, alert, and possessed of his faculties of special sense, particularly good eyesight and hearing. Although the position does not call for severe physical strain, yet a man laboring under certain physical defects may, at a critical time, be handicapped by such defects so he cannot measure up to the strain placed upon him. Likewise a man who is suffering from some passive ailment such as disease of the heart, lungs, kidneys or nervous system would be liable during a period of unusual strain, as in time of a disaster, to suffer an acute attack

and become a further menace rather than an aid to rescue work. A man subject to fits, vertigo, fainting spells or epilepsy should never be employed as a hoisting engineer. Those conditions are frequently of very sudden onset and if an attack occurred while the hoist was in motion, the danger to any men who might be on the cage at the time is apparent.

Eighty-one applicants have filed reports of their physical examination. An analysis of the findings in these reports is given below.

NATIONALITY

U. S. A.	53	England	12
Finland	5	Sweden	4
Norway	2	Canada	1
Hawaii	1	Austria	1
Italy	1	Servia	1

The above table shows that of the 81 applicants more than 65 per cent were American born.

AGES

Under 25 yr.	4	25 to 35 yr.	27
35 to 45 yr.	20	45 to 55 yr.	20
Over 55 yr.	10		

Eighty-two per cent of those applying for positions as hoisting engineers were between the ages of 25 and 55 years. The youngest applicant was 22 yr. of age and the eldest was 66 yr. of age.

EXPERIENCE

Less than 6 mo.	5	6 mo. to 1 yr.	8
1 to 2 yr.	9	2 to 5 yr.	12
5 to 10 yr.	17	More than 10 yr.	28

Two applicants failed to state definitely the time they had been engaged in hoisting. It will be noted that in all but 13 instances the returns show that the applicants had experience covering more than one year.

The physical examinations show in most cases that the applicants were in good general physical condition. In two cases summary refusal of certificates was recommended. Case I. A man of 61 yr., both eyes 20/50, right ear 50 per cent normal, left ear 25 per cent normal and exaggerated reflexes. Case II. A man 40 yr. of age, lost reflexes, suffering from occasional vertigo and presenting a history of syphilis.

In several cases where the eyesight was defective but capable of correction by properly fitted glasses and in a case of hernia where no statement was made as to applicant wearing a truss, action was held in abeyance until report could be made showing these defects had been corrected.

Twenty cases of defective vision ranging from 20/30 to 20/100 without glasses were shown. Most of these cases were very slight and all were corrected by glasses except three. Case I. Right eye 20/20, left 20/100. A letter was written to the applicant suggesting the advisability of having his eyes examined and glasses fitted, and requesting a report from the optometrist as to the results obtained. The report of the optometrist showed a correction in the case of the left eye of 20/50. Case II. Both eyes 20/60. Letter written as above. Report of optometrist showed correction to 20/30 with possibility of return to normal after wearing glasses. Case III. Both eyes 20/70. Letter written as above but as yet no reply has been received.

Four cases of minor defects of limbs were reported, the result of old fractures, but in no instance was the deformity of sufficient consequence to debar the applicant from the position of hoisting engineer.

Three cases of hernia were reported, two of which were fitted with trusses. The remaining case failed to state if truss was worn and a letter was forwarded seeking this information. As yet no reply to this letter has been received.

On qualifying for the physical examination, hoisting engineers are provided with a card certificate entitling them to practice their trade.

As far as has been determined there has been no objection raised to the examination by the hoisting engineers. Those who have expressed themselves to the commission's inspectors have been favorable toward it. It is well recognized in the mining industry that hoisting engineers, as a class, are men of good judgment, fair-minded, and dependable, and it seems that the engineers of Utah have taken the attitude that could be expected of men of that class.

In reference to the re-examination of the men yearly, the analysis of the results of the first examination shows that many of the men will be physically fit for a good many years, while others, who have a tendency toward some weakness, should unquestionably be examined yearly. It may be found advisable to allow the examining physician some discretion as to the completeness of the re-examination, having before him the results of the examination of the previous year.—U. S. Bureau of Mines, Reports of Investigations.

Copra Meal as Fuel

TESTS BY THE BUREAU OF SCIENCE EXPERIMENT STATION IN THE PHILIPPINES, SHOWING ITS UTILITY FOR BOILER HEATING AND GAS MAKING. BY CHARLES W. GEIGER.

EXPERIMENTS to ascertain the value of copra meal as fuel have been made by the Bureau of Science in its producer-gas plant at Manila, P. I. There are large quantities of cocoanut meal in the Philippine Islands, but no means of transportation is available to get it to a market.

The plant in which the experiments were conducted is a 67-hp. Otto suction producer-gas plant designed especially for low-grade Philippine coal. It consists of a producer and its auxiliaries, and a gas engine direct coupled to a 50-kw. dynamo. It has worked efficiently on copra and other fuels. Copra meal has an available heating value of 15,297 B.t.u. The results of a 10-hr. test in the producer-gas plant, where an average of 220 lb. of fuel per hour was used, showed a consumption of 7.1 lb. of copra meal per net kilowatt-hour. The best record for Fushan coal in the producer-gas plant showed a consumption of 2.82 lb. of fuel per net kilowatt-hour, and the consumption of average coal as fired under a Bureau of Science water tube boiler unit for the production of electric current shows a consumption of over 6.6 lb. of coal per net kilowatt-hour.

Cocoanut meal has been advantageously fired under the Bureau of Science boilers. In an external or

elongated fire box copra meal burns excellently and efficiently without the admixture of any coal, provided it is fired in small quantities at very short intervals. If copra meal were burned in a furnace provided with a mechanical stoker and having a grate similar in design to the type used in burning rice husks, the loss of heat due to opening the furnace door for firing would be obviated and a still higher efficiency obtained. For fuel purposes a ton of copra meal is equivalent to about 0.6 ton of ordinary (Tagawa) coal.

The ash resulting from the combustion of copra meal is very valuable on account of its potash (K_2O), and wherever copra cake is burned, the ash should be saved. Potash is a fertilizer ingredient of which the original copra meal contains 2 per cent. All of this may be recovered in the ash unless a portion is volatilized. In the boiler plant the quantity of ashes collected from the pit is relatively small, due to the amount of powdered fuel and ashes carried over the bridge wall. Any deposit that collects on the boiler tubes may be easily blown off.

Cocoanut Shells and Husks Used for Fuel

The Bureau of Science has received a great many inquiries with regard to the uses for cocoanut shells and husks. Experiments have therefore been conducted that demonstrate their usefulness for fuel.

The fuel value of air-dried cocanut shells and husks is shown by the following data:

	Shell	Husk
Moisture, per cent...	11.75	14.71
Available B.t.u.....	16,110	15,003
Total B.t.u.....	17,967	16,654

The most economical use of cocoanut shells as fuel is in a properly designed producer-gas plant, as described under "Copra meal as fuel." Tests have been made that have shown that about 6.6 lb. of shells (from 10 cocoanuts) are required to develop one kilowatt-hour at the switchboard. This efficiency probably can be increased as more experience is acquired in burning them. One pound of cocoanut shell is equal in heat value to about 0.65 pound of Japanese coal. However, in comparing the value of two fuels, the factors of the cubical measure of a given weight as it influences the expense of transportation and marketing, and whether or not the furnace is adapted to the use of the particular fuel, are especially important. Cocoanut husks are so bulky that they can scarcely compete with coal as fuel for boiler furnaces, unless it is feasible to bale them so as to reduce their volume. In the Philippine Islands the annual crop of cocoanuts totals about 431,387,000 nuts. Practically all of these, with the exception of those used for local consumption, are turned into copra. The shells are obtained by this process. The nuts are broken open and usually permitted to dry in the sun, although sometimes they are kiln dried, until the meat of the cocoanut is separated from the shell. The growing of cocoanuts is the second largest industry in the Philippines and is constantly increasing.

Power Plant Bureau of Science

The electric curent generated and delivered at the switchboard for the year 1917 was 243,198 kw.-hr., at an average cost per kilowatt-hour of 0.0803. The cost per kilowatt-hour of electric current was slightly greater than for the previous year on account of the higher price of coal and other materials. Current is used for operating numerous testing machines and other equipment maintained by the Bureau.

The total amount of steam generated in the boilers for the year 1917 was 17,113,344 lb., at an average cost of $0.001,728 per lb. The total gas generated for laboratory purposes was 1,237,470 cubic feet. The average cost of production was $1.59 per 1000 cu. ft. The power plant is a very substantial structure and is immediately in the rear of the main building of the Bureau of Science.

Analysis of Fuels

Samples of coal are continually brought to the Bureau of Science by prospectors from new districts for analysis and valuation. A great deal of advice has been given with regard to prospecting, development work, the operation of Act. No. 2719 to provide for the leasing and development of coal lands in the Philippine Islands, etc. In order to encourage prospecting in new districts of which the Bureau of Science has no record, an analysis of the first sample of each variety of coal is made free of charge, provided that it is accompanied by reliable detailed information. There have been several requests for steaming tests. Owing to the difficulty of transportation, it has been impossible to send the necessary quantity of some varieties of coal to the laboratory. Producer-gas tests have been made, and the plant has been operated efficiently on several varieties of coal. Producer-gas tests have also been made on refuse lumber and a mixture of lumber and sawdust, bagasse.

New Type of Hydraulic-Turbine Runner*

Development and Advantages of Suction Turbine. By Forrest Nagler

IN 1907 AND 1908 the author was connected with experimentally improving and testing of some large-some rather extensive field work comprising erecting, size axial-flow or screw pumps. This work concentrated all attention on a single type of hydraulic impeller for over a year and it was only natural that impressions then formed should greatly influence his trend of thought in later work, which has been exclusively along hydraulic-turbine lines. At any event the effect was such that the accepted form of reaction (Francis) runner, then and still the basis of practically all low-head turbine design, seemed unnecessarily complicated and without logical justification from any hydraulic or mechanical standpoint. These ideas crystallized in 1913 when definite application of the axial-flow principle was shown as giving inherently less wetted surface, simpler passages and greater mechanical strength than the corresponding reaction runner having radial inlet and axial discharge.

To bring out the comparison most effectively the

* From a paper read before the A. S. M. E.

initial drawings showed the axial-flow runner sketched in on the outline of the reaction runner, using the same runner band and showing the additional advantage of being able to use either the usual radial inlet guide case or the straight axial case. Most but not all of subsequent commercial applications have been along the former lines; but undoubtedly the still greater simplicity effected by the latter, especially in horizontal settings, will bring it into prominence. Models were made with the least possible delay and theories checked out practically with actual runners. New lines of improvement naturally became evident during trials, but the original profiles were left fundamentally intact, with the result that the form of turbine runner shown in Fig. 1 was developed. Inspection of this figure reveals the fact that the entire design is based on a straight radial blade, which offers the absolute minimum of wetted surface and of bending moment on the root of the blade. It is by reason of these two fundamental advantages emphasized by the simplicity and inexpensiveness of the design that the author believes the new

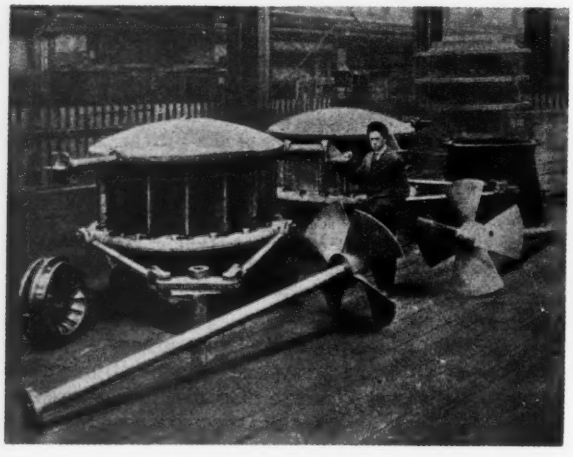


FIG. 1. ONE OF THE FIRST COMMERCIAL APPLICATIONS OF THE NEW SUCTION TYPE OF RUNNER

type of runner will supersede the mixed-flow or Francis type. Runners of practically the axial-flow type but roughly conical in profile may possess certain desirable features of strength or form of passage, but the measure of their advantage is largely indicated by the nearness with which they approach the flat form.

Tests on models were verified by Holyoke tests in 1917, the initial design being used partly for commercial reasons and partly for historical purposes. Only one design of blade was tested, although two runners, one having three and the other four blades, were also given runs. A typical set of results of these initial tests, although they do not equal in efficiency later tests obtained on improved runners, were nevertheless used in plotting some of the curves in Figs. 2 and 3. Comparisons are confined to speed and capacity for the purpose of this description and previous best results are also plotted in Figs. 2 and 3. The basis of these curves is taken directly from Professor Zowski's comparisons in Engineering Record of December 26, 1914, and it should be noted that they are plotted to show comparative powers on the basis of constant speed. This power basis exaggerates the comparison considerably over the characteristic-speed basis, but is retained to permit of direct reproduction of curves showing results typical of the state of runner development prior to the author's work.

Referring again to Fig. 2, the highest speed ordinarily offered in commercial work is typified by curve No. 4. Contrasted to this are shown curves Nos. 1, 2 and 3, the second of which is deduced directly from the Holyoke test data. The most definite indication of the field of application of the new form of runner is obtained from Fig. 2, on the following basis:

> Under any given conditions of head and with such minimum limit of speed as might be imposed by consideration of cost, efficiency and floor space, runner No. 1 will give 140 per cent and runner No. 2 will give 65 per cent more power than runner types previously available as typified by No. 4.

Comparison on a speed basis using equal power would illustrate the application of the new type as follows:

> Under any given condition of head and power, runner No. 1 will give over 50 per cent and runner No. 2 will give 30 per cent higher speed than runner types previously available as typified by No. 4.

Figure 5 is a reproduction of the "equal efficiency" diagram of the December 26, 1914, Engineering Record article. The scale has been extended to permit of showing the relative location of the new point of best efficiency and the great flexibility inherent in the new form of runner. The diagram of runner No. 3 is shown at the right on repeated abscissas in order to avoid too much overlap of diagram and consequent confusion. The ordinates remain the same. The shape of the "efficiency hills" is somewhat different from that of the mixed-flow runner, although perhaps not as much so as might be expected from the great difference in runner forms. That the guide cases (gates) were of the same design for both forms may be somewhat responsible for the runner not showing greater diversity in characteristics.

Figure 3 presents an excellent basis for showing the contrasting speed characteristics of runners. Obviously their having been recomputed to 50 r.p.m. causes all the highest efficiency areas to lie on the same vertical line. This simplifies comparison in that the horizontal width of the equal-efficiency areas indicates flexibility of the runner or its ability to maintain good efficiency under varying speed or head, the latter being the variation encountered in commercial application. The position of the highest efficiency area on the vertical ordinate indicates whether it is of a high-capacity or low-capacity type or similarly whether it is a high- or low-speed runner. Its suitability for low-head work is determined largely by its vertical position.

Commercial Advantages

Numerous and sometimes unexpected advantages have been found to result from the simple and open form of runner. For example, a runner may be taken out and another substituted for capacity variation under flood conditions or for test purposes without removing

any other turbine parts except two or three guide vanes. In two plants this was made use of to install a high-capacity runner for obtaining more power during flood periods. Likewise these higher-capacity runners were made by using the original core boxes, which means that blade angles were unchanged, the result being accomplished simply by using a different number of blades.

The greatest mechanical advantage arises from the fact that the runner cannot clog up with sticks, blocks, leaves or other debris, a feature which the author's experience with the average low-head installation would indicate should result in several hundred per cent more power the year round.

The primary advantages which were anticipated and which have proven out in practice are as follows:

a Lower generater cost due to an increased speed of 50 per cent and over above previous practice. This saving varies from 15 to 35 per cent of the generator cost, depending on its size and speed.

b Lower turbine cost due to simpler runner. This averages around 10 per cent, the runner being about one-third the weight of the corresponding mixed-flow type and much easier to build, either solid or with separate blades.

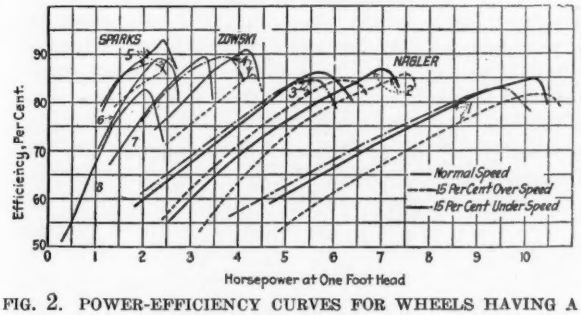


FIG. 2. POWER-EFFICIENCY CURVES FOR WHEELS HAVING A NORMAL SPEED OF 500 R.P.M.

c Smaller generator diameter, which means smaller power house.

d Higher generator efficiency due to better design possible with the higher speed. This is seldom less than 2 per cent gain and may conservatively be stated to vary from 1½ to 3 per cent.

e Greater turbine flexibility, which permits the plant to give more power under flood conditions when the head is greatly reduced. This runner has an overspeed of about 100 per cent as contrasted to perhaps 60 to 75 per cent for previous types. This means that its efficiency and consequently its power will not become zero until the head has been reduced to about one-quarter normal as contrasted to four-tenths or one-third normal for reaction types. This advantage lies not solely at the extreme limit of minimum head but at all abnormal heads or speeds, as the efficiency is less affected than with the other types.

At the present time efficiencies equaling the records of reaction (Francis) wheels have not been reached, but they are being approached rapidly and with the inherent advantage of better generator efficiency, equivalent combined results for the unit are only a matter of short time. Fundamentally the axial-flow runner should give greater efficiency than the mixed-flow purely from considerations of wetted surface and hydraulic friction, to say nothing of the simpler form permitting of greater accuracy of construction and more correct design.

Type of Runner

As to the nature of this new type of runner, it may be said that from direction of flow it is undoubtedly a pure Jonval type, although his runner consisted of

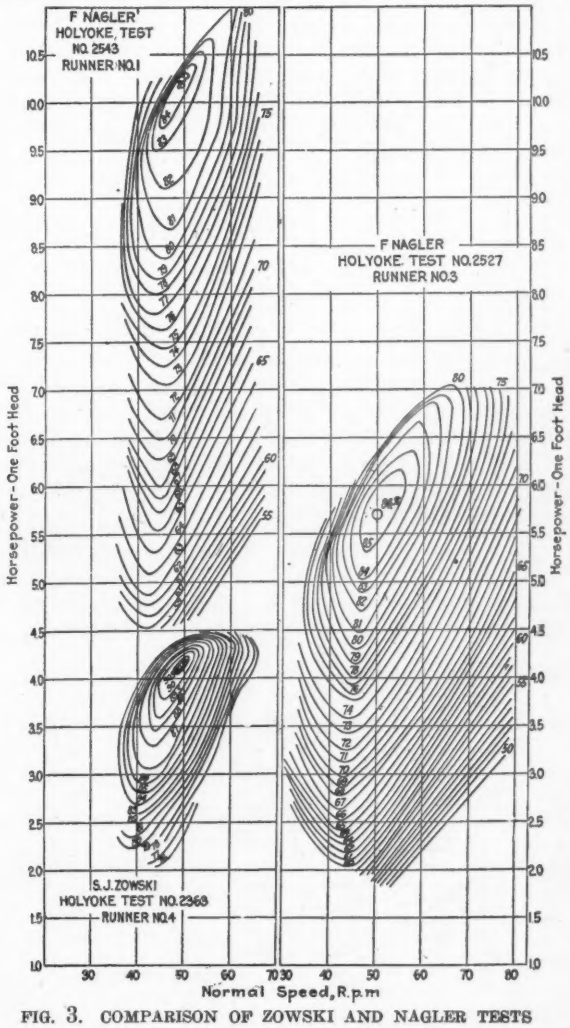


FIG. 3. COMPARISON OF ZOWSKI AND NAGLER TESTS

a narrow row of blades on the periphery of a comparatively large disk, and his characteristic speeds seldom exceeded 20 or 30 as contrasted to the present 100 to 200. Furthermore the Jonval type was a pure reaction wheel, which infers jets issuing from orifices or channels, these being noticeably lacking in the runners of Fig. 1.

Professor Baudisch in some of his mathematical studies on the design of high-speed axial-flow runners has introduced a type name which translated literally is "suction jet," the conclusions from his calculations being that in order to produce extraordinarily high characteristic speed it is essential to run into certain under-

pressure conditions such as result when velocities greater than $\sqrt{2gH}$ are produced in the throat of a diffusing nozzle discharging under a head of H feet. The term "suction turbine" impresses the writer as being quite inappropriate, but from another reason which may be outlined as follows: Underpressure is not essential to high characteristic speed, though it may frequently occur. The primary essential to high characteristic speed (125 to 200) is a reduction of hydraulic friction and harmful centrifugal forces. Neglecting friction and possibly blade thickness, there are no mathematical or hydraulic laws that will prevent doubling or quadrupling any particular characteristic speed by simply flattening the blade angles. A direct analogy to this is the well-known illustration of relative velocities evidenced in the sail of an ice boat. The practical effect of so doing with a given profile is to lengthen the blade so that the friction on the increased wetted surface reduces efficiency and speed or results in constriction of passage. In the author's design, these effects are counteracted by cutting out blades, the effect of which is not manifested in the reduction of power that might be expected. On the contrary, the discharge is increased *without* reduction of efficiency.

Investigation of thrust and power shows that the force on each blade exceeds the product of blade area and the total apparent head, which can only mean that in such cases there is less than atmospheric pressure on the back side of the blade aside from that due to draft head. This is strictly analogous to the distribution of the total force on the wings of an airplane, less than half of which is pressure from below, the remainder being suction on the upper surface. As such suction action is in evidence primarily with these high speeds, the author believes the term "suction" to be peculiarly applicable to this form of turbine runner.

Experiences at the Glendale Plant

BLAKE REPORTS TROUBLE WITH THE DIESEL ENGINE; WALLACE REPLIES, DESCRIBING SOME OF HIS PROBLEMS AT BRIDGETOWN. BY G. H. KIMBALL

DEAR WALLACE:

I was glad to get your letter and your honest opinion about this man Gooch. Since I have known you much longer, I shall be guided by your advice and I have told the manager that I did not care to run the steam end of the plant with Gooch in charge of the oil engine. Now I find that Gooch is willing to take the whole works in charge.

He certainly has the most confidence of any man that I ever knew, for, to hear him tell it, there is nothing that he cannot do and we had a sample of his work recently. I went off watch one night and he came to

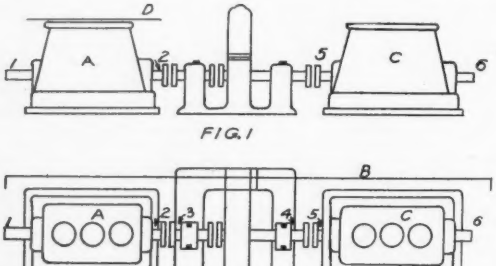


FIG. 1. METHOD OF LEVELING ENGINE HOUSING
FIG. 2. METHOD USED IN ALINING CRANKSHAFTS

relieve me. There was very little water coming down the river and the oil engine had about all that she could carry. The high tension station was closed for the night and the fire under No. 1 boiler was very low. Thinking that we might get through until the last car came in, I told him that she would not stand any more load; but he had plenty of assurance that she would be all right, so I went home.

The next day when I came in, the engine was stopped and I found, on inquiring, that after I left there had been so much load that she had overheated one of the cylinders and it had seized the piston so that he had to stop it. Of course, all of the power was shut off all over the town for a while. I cannot find just what happened, but I think that the circulating water pressure dropped on account of the water in the canal getting low and he did not notice it until it was too late.

I am somewhat surprised because he has been telling me how much he knew about Diesel engines and how little you knew in regard to operating them and that he would show them something in this rube town. Now you can see what has happened after all of that talk which might have been prevented with proper care. We had loads heavy enough to stop them when you were here and nothing like that ever happened.

We have taken the cylinder head off and after cooling the piston did not stick very bad. The cylinder is scored some but is not worn out of round much. It is a good chance to grind the valves and they must need it for they have not been touched since you were here. Most of the small tools have gone that we used to have and I noticed that Graham came here without a chest, but he had quite a heavy one when he left. Crandall, who has charge over at the Black River power house, says he is getting more water from now on so that he can help us out more, and I think that we shall need it.

I see that you are still busy down there and I hope you will have good luck with that old engine.

Your friend,
JOHN BLAKE.

DEAR JOHN:

It is now plain that a man who accomplishes little is liable to boast considerably. I am sorry for Wilbur to have a man like that working for him, for the plant will get badly run down.

It certainly is lively here at the present time. The old unit is now resting on its foundations and the carpenters have built an addition to the wooden power house over it. It is going to be a rather particular job to put everything in line for there must have been some wear on the bearings in the crank case so that the origi-

nal relation between the crank shaft and the housing has been destroyed.

The engine is now setting according to the above sketches. When the unit at Glendale was installed, the crank shafts were supposed to be parallel with the tops of the housings which were planed. Thus a level placed on them would make the shaft level and then a line as B, in Fig. 2, was stretched and with a tram similar to E, the points 1, 2, 3, 4, 5 and 6 were made equidistant from the line and that put the three sections of the shaft in line. The couplings at points 2, 3, 4, 5, were about ⅜ in. apart and a cast-iron ring or filler was fitted which could be taken out if it was necessary to run but one side of the unit. The work on these couplings was very good and they could be taken down or made up in short order.

In this case, the problem is more difficult, however, for the part marked A is the oldest. This is because it was the first oil engine that the company purchased and it ran as a three-cylinder unit with a 160-kw. generator. Later, section C was purchased and connected up to the present 300-kw. machine. So you see that the older part must be worn much more than the new and the shafts are probably somewhat out of line. To use a level on the top of the housing will not answer for the crank shafts; but the two shafts can first be made parallel to the top sides by the use of a line, D, which can be made parallel to the top and then the distances from it to points 1 and 2 made equal. The same thing can then be done to the other side and then the side line used as before. If the couplings are in line the shafts should run true. If the faces of the couplings are machined true with relation to the shafts, when everything is in line, the faces should be equidistant at all points; if this is carefully done the alinement should check with the other method.

In a case like this, I think that it is better to have a man from the engine works to see that everything is all right; but Mr. Curley, the superintendent, wishes to show what he can do, so he has had several men to help in the setting up. They say that it is in line now and I hope it is, for it will be some job to correct it after the cement has set.

I came here as an operating engineer, not as an erecting man, and I have declined to take the responsibility of setting this up, but I have been called upon to answer most of the questions that have come up. In some cases, the superintendent has not believed that I was right and he has written to the engine company, which has confirmed them so far.

I hope that you will get along all right with Mr. Gooch. Let me hear from you soon.

Yours very truly,

WILLIAM WALLACE.

Freezing Tanks*

CAN HANDLING SYSTEMS; BRINE AGITATION. BY FRED OPHULS

THE METHOD of harvesting can ice has not been materially changed since the first successful ice making plant was built. Given a proper pneumatic or electric can hoist and traveling crane handling at least two if not three 300 lb. cans at one time, a tank laborer can harvest, with all the machinery in good running order, not less than 33⅓ tons of ice in 10 hr. This means that with the present method of handling can ice the proper capacity of a freezing tank is in the neighborhood of 60 to 66 tons.

If three shifts have to be used, the amount of ice harvested by each man per hour is somewhat increased so that single freezing tanks having a capacity from 70 to 75 tons per day with the present harvesting equipment appear to be the most economical units, considering the labor cost.

From time to time, attempts have been made to improve the method of harvesting freezing tanks. Some have been equipped with mechanical devices for moving the cans in the freezing tank from one end of the tank to the other, and with cranes and hoists large enough to lift out a whole row of cans at a time, so that all harvesting can be done at one end of the tank. This construction does not, however, materially facilitate the handling of the freezing system, for the empty cans or else the cans filled with water must be brought to the far end of the tank and, therefore, no material saving has resulted in the labor cost. In addition thereto, extra expenses have been incurred in keeping up the more complicated mechanical equipment.

I might say that in some of these cases the labor cost has been reduced, but the increase in maintenance has eliminated the saving made in the labor cost. This is the reason why designers always have come back again to the pneumatic or electric traveling crane handling two or three ice cans at a time.

There are some ice making systems in which the ice cans are stationary in the freezing tank. In these systems the cost of harvesting ice has been reduced. The greater initial cost of these plants, which increases the fixed charges, that is, interest on the investment and depreciation, have in some cases offset the saving in harvest labor.

It follows that a valuable improvement in the method of harvesting can ice must not alone save labor cost, but the total expense of the labor cost plus maintenance, depreciation and interest on the investment must be less than that of the present standard can freezing tank.

There is no reason why a conveying system cannot be installed in connection with a can ice freezing tank that will materially reduce the cost of harvesting the ice, so that the time required by the tank man to bring the ice cans to the ice releasing apparatus and return them into the tank can be saved. With such a harvesting system, one can puller could handle three or four times as many ice cans a day as he can now.

If such a system is adopted, the lifting of the ice cans from the tank and returning them to the tank is

* Abstract of paper read before Eastern Ice Manufacturers' Convention, held at New York City, Nov. 12-13, 1919.

done by a tank man, whereas the releasing of the ice from the can is done by another man and if necessary in an entirely separate room from the freezing tank room. The advantages of this system are apparent when one considers that it will be possible to bring all the cans, for thawing, to one place and make full use of the length of the building for the tank proper.

The actual space required for removing the ice from the cans, if it is all done in one space, will be far less than it is today, where an ice releasing unit must be located at the end of each freezing tank.

I do not believe that such a conveying system would prove economical for ice plants of less than 100 tons daily capacity. As long as one, or at the most, two men on each shift can take care of harvesting the ice, the present system will prove the more satisfactory one unless if for some special reason it is desirable to locate the ice releasing plant on another floor level than the freezing tank floor. This situation may arise in a case where the floor space is limited and it is desired to install the largest possible freezing tank system in that space. By conveying the ice cans to either a floor above or below by an automatic contrivance, the largest possible space will be available on the freezing tank floor for ice making.

The uniform experience of the manufacturers of conveying and elevating machinery has been that packages of the same dimensions and practically the same weight are most suitable for automatic delivery. This applies in every way to an ice making plant where ice cans and ice blocks of practically the same dimensions are handled.

Cans Required

Having given due consideration to harvesting, the next problem which must be solved in connection with the freezing tank, is the number of ice cans that shall be installed in it per ton of daily ice output. This question involves not only the efficiency of the freezing tank but it affects seriously the size of the coal pile or else the amount of power required to operate the plant.

In these days where raw water ice making systems are almost universally installed when new plants are built and old ones increased or improved, this question becomes very serious. It is in this direction that I believe there is considerable room for improvement in design.

At the annual meeting of the A. S. R. E. of 1917, I presented a paper on the "Analysis of Can Ice Freezing Tanks," and in this paper I went into detail showing the manner in which ice freezes in cans, around pipes, in pipes and on plates and suggested a formula giving the freezing time in hours for freezing solid a standard 300 lb. cake for varying can freezing surface temperatures. Applying this formula to an example, we might take a freezing tank equipped with 14 1-2-300-lb. ice cakes per ton of daily ice output. In this tank the ice cakes must be frozen solid in 52.2 hr. and calculations show that if the freezing surface or the surface of the ice can is maintained at 21 deg. F., that the 300 lb. standard block will freeze solid in that time. If it were possible to immerse the cans in liquid ammonia, the back pressure on the ammonia system could be maintained at 34 lb. gage.

Most of the freezing tanks equipped with this number of cans per ton operate on a back pressure varying from 15 lb. to 17 lb. and with an average brine temperature of from 12 to 14 deg. F. This shows that there is a considerable discrepancy somewhere and it should be possible to improve the construction of the freezing tank to bring its operation nearer to ideal conditions.

There are several ways to effect an improvement in the operation of the standard freezing tanks. The first is to increase the efficiency of the liquid feed system to the brine cooling coils. A great many have had experience with the various flooded systems which have been designed for the purpose. It has been found that we must be very careful in adopting the flooded system for the brine cooling coils as the results obtained have not been uniformly satisfactory. The reason for this is that the success of the flooded system depends on the size and length of the brine cooling coils and on the amount of heat which must be removed per square foot of brine cooling coil surface in the freezing tank. If any of these factors are not properly taken care of the flooded system will be a failure, that is, it will not operate successfully as a simple direct expansion system. The object of the flooded system is to have the largest amount of liquid ammonia possible in direct contact with the brine cooling coil surfaces and to obtain this end, an excess quantity of liquid ammonia must pass through the cooling coils and the arrangement of the separator must be such that only saturated ammonia vapor reaches the refrigerating system.

The main factor which will improve the economy of a freezing system is the agitation of the brine. The more rapidly the brine circulates between the cans, the more effective will be the transfer of heat from the ice can surface to the brine cooling coil surface.

Formerly, when freezing tanks were installed with agitators which barely caused a flow of brine between the cans, it required from 20 to 24-300 lb. cans per ton of daily ice output. Then, as agitation was improved or which is more to the point, as it was found that in an ordinary distilled water ice making plant the back pressure could be carried at 15 lb. without obtaining too much distilled water for filling the cans, the number of ice cans per ton of output was reduced to 10 cans or less.

The question of the number of ice cans is at this time in such an unsatisfactory state that a careful investigation carried on in existing plants would be of the greatest value. These investigations require considerable time and some layout of funds and it is therefore difficult to get the manufacturers of ice to make the experiment necessary.

For instance, if one wishes to investigate the action of varying the speed of brine flow in a freezing tank thoroughly, it would be necessary to provide in the freezing tank some means for holding the cans in a vertical position, otherwise, the high speeds which my analysis of freezing tank variation have shown to be desirable, cannot be tested out, for the cans would tip over. Furthermore, the agitation system would have to be made sufficiently flexible that a considerable variation in the brine speed would be possible. The size of the freezing tank also is of considerable importance in making these tests, for if the tank is too large and is long in comparison to its width, it will be difficult to increase the agitation materially without raising and correspondingly lower-

ing the brine level at the ends of the tanks unduly. Such experiments, however, would be of enormous value and would enable the designer to bring the efficiency of the freezing tank on the same level as the efficiency of other parts of the ice making system.

The raising of the brine level due to increased agitation is also an important factor and brings with it an entire change in the design of freezing tanks for high brine flow.

Taking as an example a freezing tank containing 1062 cans, the freezing tank being approximately 22 ft. 4 in. wide and 135 in. long, this tank has with the usual agitation, an approximate capacity of 66⅔ tons. It is impossible to increase the brine flow in such a single tank to exceed 60 ft. per minute without unduly raising the brine level at the ends. As the calculations indicate that a brine flow of 120 ft. or more would be economical, the construction of such a tank would have to be somewhat changed in order to allow for the increase in agitation. My suggestion would be to divide a tank of this size by a partition running across the tank into two equal freezing tanks and provide separate agitation for each one of the two parts. This would mean agitating two tanks approximately 67½ ft. long and 22 ft. 4 in. wide which can be done for high brine speeds without raising the brine level at the ends more than 2 in. or even less.

Maintaining the same output for the tank when increasing the brine agitation the benefits derived from this improvement will result from a considerable increase in the ammonia back pressure which can be carried in the brine cooling coils. Ordinarily a tank of this size operated with the usual agitation will make 66⅔ tons of ice at a back pressure of approximately 18 lb. The boiling point of ammonia at 18 lb. gage is about 4 deg., whereas the average freezing tank surface temperature to produce this capacity would be 22 deg. F. We have there a difference of 18 deg. F. required to transmit the latent heat from the water to be frozen to the ammonia in the brine cooling coils.

The object of increasing this agitation is to reduce this difference in temperature. The more rapid flow of the brine in the tank causes a more thorough mixing of the brine as it flows through the tank and a correspondingly higher transfer from the freezing surface of the cans in the brine cooling coil surface. It is easily possible to reduce this difference of 18 deg. by one-half so that the boiling point of the ammonia in the cooling coils would be 13 deg. instead of 4 deg. We would then obtain an ammonia back pressure in the cooling coils of 26 lb. gage which increase in back pressure would directly affect the horsepower required to operate the refrigerating system.

To compress saturated ammonia vapor from 18 lb. gage to 185 lb. gage requires approximately 1.6 hp. per ton of refrigeration. Figuring that 1½ tons of refrigeration are required in the freezing tank per ton of ice made, the refrigerating machine operating the above freezing tank would have to develop 160 hp. The same tank giving the same capacity of 26 lb. gage suction pressure and a discharge pressure of 185 lb. would require an expenditure of 1.35 hp. per ton of refrigeration or a discharge pressure of 185 lb. would require an expenditure of 1.35 hp. per ton of refrigeration or a total of 135 hp. at the refrigerating machine.

From these approximate calculations, it appears that a saving of 25 hp. would result due to an increase in the speed of the brine that will produce an ammonia suction pressure in the brine cooling coils of 26 lb. gage. This brings up the question as to the agitator power necessary to produce this increase in brine speed.

I have made some investigations on horsepower required for agitation in freezing tanks and an analysis of this investigation is given in the paper to which I referred before. The freezing tanks from which my figures were taken had submerged can, coil and tank surface varying all the way from 4000 sq. ft. which is a considerable range. The velocities of brine flow varied from 104 to 240 ft. per minute and I found that the horsepower required for agitation varied directly as the wetted surfaces submerged in the freezing tank and only increased very slowly with an increase in the speed of brine flow; that is, for a tank having a wetted submerged surface of 10,000 sq. ft. operated at brine speeds varying approximately from 100 to 200 sq. ft., the increase in horsepower when the speed of the brine was not directly in proportion to the speed of the brine.

You will appreciate that even in the case above cited that an increase of 5 hp. in the operation of the refrigerating machines would be a small price to pay.

The proper length of brine cooling coils, or better, the amount of brine cooling coil surface for freezing tanks, is a rather difficult matter to determine accurately. Information available is meagre and it is impossible to form a clear judgment in this case until authoritative experiments have been made to settle this question once for all. The variables involved in this factor of the freezing tank are so many that I am rather loathe to go into this matter any further. There are, however, some outstanding facts which it might be worth while to review.

You all know that before the use of the flooded system it was customary with the straight direct expansion system of feeding the brine cooling coils to use 300 ft. 1¼ in. pipe per ton of ice making capacity in the freezing tank. This is equivalent to about 130 sq. ft. of effective brine cooling coils surface and under these conditions the average brine temperature was about 14 deg. F. and the suction pressure in the brine cooling coils about 15 lb. gage which is equivalent to a boiling point of 0 deg. for the ammonia. To produce one ton of ice in the freezing tank under ordinary conditions requires about 1½ tons of refrigeration so that we have here all the factors necessary to figure the heat transfer co-efficient between the can surface and the brine cooling coil surface. Equating these figures, we find that the heat transfer co-efficient in this case is 10 B.t.u.

When using the flooded system of feeding the brine cooling coils it is usual to use a maximum of 200 ft. of 1¼-in. pipe; the other conditions being the same. The heat transfer co-efficient in this case would be 15 B.t.u., that is, 50 per cent more than in the first case. The reason why the heat transfer in the case of the flooded system is better than in the other is that a properly constructed flooded system will feed an excess quantity of liquid to the cooling coils which in turn will result in a larger part of the cooling coil surface being wetted with liquid ammonia.

In the case of the freezing tank which I have referred to before where the difference between ammonia boiling in the cooling coils was only 6 deg., the flooded system was also used and the heat transfer co-efficient figured out on the same basis is 34.6 B.t.u., that is, over double the former value.

The reason why the heat transfer was increased in the latter case was that there was a greater agitation of brine in the freezing tank.

From all the information that I have been able to gather on this subject, I have adopted the following formula for finding the heat transfer for the brine cooling coils. This formula is as follows:

$$k = 2.5\ Vv.$$

In this formula k is the heat transfer co-efficient in B t.u. per hour per square foot of effective brine cooling coil surface per 1 deg. temperature difference between the average brine temperature and the boiling point of the ammonia in the brine cooling coils; v is the average speed of the brine in feet per minute.

Applying this formula to the two cases in which the flooded system was used, I find that the speed of the brine in the first case was approximately 35 ft. per minute and in the last case 192 ft. per minute. By the use of this formula it is possible to approximate closely the effective brine cooling coil surface which will produce the results desired in any particular cases.

Briefly summarizing the changes in design which would be necessary for higher brine speeds, it appears that:

First, more attention will have to be paid to the size of the freezing tank, that is, its length in comparison to its width.

Second, the spacing of the cooling coils should be considered. The closer the cooling coils can be placed in the tank the less will be the agitation required to secure a certain result.

Third, to maintain high agitation in a freezing tank some means must be provided for holding the ice cans in a vertical position. This result can be easily secured by furnishing for each can a metal strip reaching from the framework to the bottom of the woodwork of the tank against which the can can rest.

Fourth, the area of the agitator troughs, size of the propellers, the number of propellers require careful design.

Practical Pointers on Refrigeration

OUTLINE OF THE COMPRESSION SYSTEM AND HINTS ON CARE OF MACHINERY AND THE MIXING OF BRINE. BY LINCOLN S. SPENCER

WHEN I came on duty on my present position over 5 yr. ago, I never had seen an ice machine and I was a bit nervous; but I went at it and I think that what I have learned may be of some help to a beginner.

In refrigerating with compression system, we must have a compressor and a power to drive the compressor, which in my case was a steam engine direct-connected to compressor.

Some compressors are connected like an angle compound engine with engine horizontal and compressor vertical, giving and taking power from the same crankpin. My engine and compressor were both vertical. There must be a heavy flywheel, as these engines run slowly and are heavy loaded; the load is like the load of a duplex pump and the flywheel is necessary to make the engine run steady.

The compressor has two cranks and pistons set at 180 deg. apart, so when one is compressing or discharging, the other is taking in its charge. These pistons are trunk pistons fitted with snap rings, the valves of which are constructed wholly of steel or iron. You cannot use other metals with ammonia, for it will eat them up in a short time, causing leaks and all kinds of trouble. The cylinders and valve chambers are water-jacketed to prevent being overheated caused by compression of the ammonia.

The base or crank chamber is filled with a special oil (pure mineral), for a fatty oil coming in contact with the ammonia gas will foam and leave the compressor with the gas. The oil lubricates the cranks, wrists and cylinders of the compressor, also the main bearings of the compressor. The cranks run in a splash which throws the oil and does the lubricating.

Now, as this oil is in a spray, more or less will be drawn over with the ammonia gas, so we must have an oil separator to prevent filling our system with oil and cutting down efficiency of our plant. This separator is a cast-iron tank. Ours is about 5 ft. long and about 12 in. in diameter. The discharge from the compressor runs about halfway down inside of the drum and the discharge from the drum is at the top allowing the oil to drop to the bottom, which must be drawn off when any amount has accumulated.

There is a connection in the base of the compressor or crank case so that when the system is pumped down to a vacuum, this oil may be drawn back into the compressor. Fresh oil may also be put in through this connection.

Now, if you want to repair either side of the compressor, low or high pressure, the ammonia must first be removed, which is done through a bypass with main expansion valve closed and the discharge valve on the compressor closed. Open bypass and the ammonia on the high side can all be pumped into the low, then close valves and you may work on the high pressure side. Great care should be used when you disconnect any of these pipes, for there will be a certain amount of ammonia gas that the compressor cannot get which might prove injurious to the workmen if they are not careful.

There is an oil trap on the suction pipe near the compressor to take out oil if any should happen to come back with the ammonia gas. This trap is connected with base of compressor and needs no particular attention, only to be cleaned once in a while.

There is a compound gage on suction or return pipe and a high pressure gage graduated up to 300 lb. on high pressure side (or discharge side). This is a compound gage also. The springs in these gages are made of steel. There must be a safety valve inside of the

stop valve on the high-pressure side to prevent the bursting of pipes or blowing off caps of valve chambers in case somebody should start up with the stop valve closed, or the circulation of water stop in the condenser. The valve should open at 250 lb. and be fully open and not let pressure exceed 275 lb. per sq. in. All pipes and fittings should be extra heavy. This valve must be a direct spring loaded type (not a pop).

Lift of valve disc from seat at 275 lb. pressure shall be at least 1/6 of normal diameter of valve. The valve is cone pointed to prevent the least possible resistance to the flow of gas and is turned to an angle of 60 deg. to the seat, which is reamed 1/32 in. wide, the angle being 57 deg., allowing the valve to seat on a sharp edge instead of flat surface. Valves must be so constructed as to stand this seating.

The discharge pipe goes from the compressor to the oil separator and from separator to condenser, which is a set of pipes through which the ammonia gas must pass. This condenser is one set of pipes inside of another set; cold water circulates through inside pipes and the gas is between the inner and outer pipes, being cooled to a liquid state by the water and the outside air, thus taking away the heat caused by compression, also the heat the gas has taken up or absorbed from the rooms cooled. The ammonia leaves the condenser in a liquid state and goes to expansion, or storage tank. The ammonia goes from this tank in a liquid state to rooms to be cooled or to the brine tank in case you have a brine system, or both brine and direct expansion. There are expansion valves in every room to regulate the flow of liquid.

The ammonia in the condenser flows in the opposite direction to the water, which is also the case in the brine coil; ammonia flows one way and the brine the other. One pipe is inside the other, same as condenser. This causes brine to circulate freely in direct contact with ammonia pipe or cooling coil and takes the coldest brine to the rooms to be cooled. It also prevents brine from freezing by keeping it in good circulation.

Ammonia

Our common ammonia, known as hartshorn, etc., is a solution of ammonia gas and water, and its usual strength is 26 deg. Baumé, known as 26 deg. ammonia. Anhydrous ammonia, the other commercial ammonia, is a liquid gas and must not be confounded with the ordinary liquid 26 deg. The difference is that liquid anhydrous is without water.

I wish to say here that one part of water will absorb 800 parts of ammonia gas at 60 deg. F. Ammonia gas is half the weight of air, so in case of accident and ammonia gas is escaping, use a hose if possible and keep as close to the floor as possible.

Anhydrous ammonia is a pure dry amomnia gas compressed to a liquid. Anhydrous ammonia boils at 27 deg. below zero F. Ammonia is composed of one part nitrogen and three parts hydrogen. A large portion of our commercial ammonia liquor is obtained as a by-product in the manufacture of coal gas or coke.

To Fill and Start System

First start your engine and compressor and pump down to a vacuum, have your drum of ammonia on scales and pipe connected to the low-pressure side of the system near the expansion tank. Be sure the main expansion valve is closed, then open the valve slowly on ammonia tank and let in the desired amount, which you can tell by continually weighing the drum as you have it already on scales for this purpose. Then see that all expansion valves are closed and open the main expansion valve; then the expansion valve to each room should be just cracked open so you can hear gas pass through. Watch closely your return pipes and see that they do not frost back and freeze up your compressor. Watch return from each room and you can tell what is going on in each room. They should be frosted outside of the room to get good results. When the coils are in two sections, one expansion valve might be open too much and the other not enough, causing return pipe to frost back and at the same time not do the work in cooling the room. This you can tell by listening to the expansion valves in the room. Set valves to sound alike and if then they frost back, close down on them alike.

If the return frosts back on the compressor, it will cause oil to leave the compressor with the gas and if you do not stop the ammonia from coming back so strong and drain the oil separator at once, you will fill your system with oil. This you must watch closely.

After starting up an ammonia system, after it has run a few hours to get things regulated as stated above, shut it down and let it stand a few hours, then purge system. This is done with a small pipe connected to the highest point on the high-pressure side with a valve close to where small pipe leads off. Run this pipe to a convenient place, preferably out of doors, take pail of water and put under the pipe, the pipe being submerged, just crack the valve and the air that will be at this highest point in the system will escape through this pipe and pail of water. Watch closely, for when air is out, ammonia gas will come and when the gas leaves water, it will look white like steam, then close the valve quickly. This is a job that requires care.

At all times, a man should be watching for leaks and keep everything up in shape, for ammonia is dangerous to handle. Test for leaks with sticks dipped in melted brimstone, set on fire, hold around the joint and if it leaks it will show a very white smoke. You can also use turmeric paper for tests. If paper turns brown, there is a leak, if paper remains yellow, the joint is tight.

If you get oil into your system, pump ammonia out of system, blow out all coils with steam to clean coils, then blow out with air to get rid of water left from your steam. Use ammonia compressor for air compressor if you have no air compressor.

Brine

Refrigerating brines must be operated at so close to zero, which is the freezing point of saturated salt brine, that crystals of salt separate. The solid salt crystallizes the inside of pipes or outside in brine tank, it clogs circulation and insulates the pipes against cold, and wastes power by requiring increased circulation. It also corrodes iron pipes so freely that it causes leaks, repairs, etc., to offset the low cost of salt brine.

If two kinds of pipes are used, iron and brass, wrought and steel, etc., a mixture of several chlorides

sets up action like an electric battery and dissolves the metals. These troubles are hastened if you have a leakage of electric current onto pipes.

Calcium chloride contains less of these substances and lessens the cost of repairs, gives lower freezing point and is much better to handle.

Return pipes should discharge below the surface of brine to avoid saturation with air, which if allowed exposed to air will in time become acid and corrode.

Calcium chloride brine made from 75 per cent salvoy calcium chloride if allowed to become acid may be made alkaline by hanging a bag containing a few lumps of slaked lime in brine tank near return pipe. Salvoy calcium chloride, if kept alkaline, will not corrode the pipes or ice cans.

Calcium chloride brine is made by dissolving 100 lb. to 6 gal. of water, add water and test out with hydrometer to get freezing point. We use 3 lb. to a gallon of water and find it freezes at 12 deg. below zero.

Salt brine is made up of 266.81 lb. pure dry salt to 100 gal. of water. The strength should be 22 deg. Baumé. Brine is made of common salt, calcium chloride or sodium chloride and chloride of magnesium in water. I should recommend using calcium chloride.

The brine system consists of a tank of brine made as above stated. There is a pipe leading from tank to pump and from circulating pump to rooms to be cooled, through coils in rooms and return by gravity to tank. Temperatures are regulated by the amount of brine circulating through coils regulated by valves in each room. You must remember that the brine must be kept cold or the circulating amounts to nothing. If circulation stops, you must shut ammonia off coil to prevent brine from freezing and bursting the pipes.

Anhydrous ammonia comes in steel or iron drums in a liquid form, is taken into system as stated before, is drawn around through compressor to condenser as a gas, where it is condensed to a liquid state, and flows from condenser to main expansion tank or storage drum. Now, as anhydrous ammonia is a liquid gas or gas compressed to a liquid state, you see that as soon as it is given a chance to expand, it goes from a liquid to a gas. This ammonia is taken from expansion tank in a liquid state to each expansion valve in each room to be cooled and when these valves are just cracked to allow ammonia to pass through, as soon as it leaves high pressure at about 150 lb. per sq. in. and passes into expansion coils or cooling coils at nearly atmospheric pressure, or 5 or 10 lb. gage pressure, it becomes a gas.

As the ammonia goes from a liquid to a gas from the high to the low pressure, it causes the gas to become very cold. This cold gas cools the pipes and absorbs the heat in the rooms, the compressor takes back gas heat and all and compresses it to high pressure. It is then very hot. It goes from compressor to condenser and is cooled to a liquid by water, which takes away the heat caused by compressing and the heat the gas has absorbed from the rooms cooled.

Ammonia gas at a pressure of 0 lb. to sq. in. has a temperature of 30 deg. F.; 2 lb.—25.2 deg.; 4 lb.—20.5 deg.; 10 lb.—6 deg.; 60 lb.—40.4 deg. So you see when the pressure is increased, the temperature increases or raises and as it is allowed to expand from a high to a low pressure it does the trick.

Opinions differ as to the amount of back pressure to carry, but I find that from 2 to 5 lb. is the better in our plant under ordinary conditions, but in summer or when the temperature of rooms is up, the back pressure will increase and as the temperature in rooms drops, your back pressure decreases and you must watch and not let your compressor freeze. As the temperature in rooms drops and the expansion valves are all set the same and there is not the heat to absorb, the ammonia comes back stronger and you must cut down on your expansion valves or freeze up your compressor. You must never let enough ammonia through expansion valves to liquefy in coils.

The tonnage of an ice machine is rated as follows: A machine rated at 10 tons means that it would do in 24 hr. the same amount of work as 10 tons of ice would do, going from solid state to a liquid state at 32 deg. F. To melt one pound of ice at 32 deg. F. requires 142 B.t.u.

One ton would require 2000×142, or 384,000 B.t.u. It requires from 50 to 55 sq. ft. of surface per 24 hr. ton, maximum capacity.

Pipe 1½ in. in diameter has a flat surface of 0.494 for each foot in length, or 49.4 per 100 ft., so it would take a little over 100 ft. of 1½-in. pipe for 24 hr. ton (in your cooling rooms).

Keep all valves free and easy to close in case of accident. Look out for loose bolts or rusted nuts, pitted pipes, pipes eaten thin close to flanges where brackets come in contact, scale on outside, oil on inside, cracked flanges or fittings, poor water circulation, packing of glands or double pipe condensers.

The pipes in cooling rooms become frosted, sometimes very thickly; even ice is formed, due to moisture collected from the room. This must be kept off by some means, for it cuts down your refrigerating capacity by insulating the pipes. This may be scraped off with a scraper, by hand, or an easier way—by putting a trough under the coils and filling it with granulated calcium, which will absorb the moisture. The calcium must be changed as it becomes saturated. We have never tried this, but I am told that it works well. This saturated calcium can be used in the making of the brine.

The Pyramid of Success

By Jack L. Ball

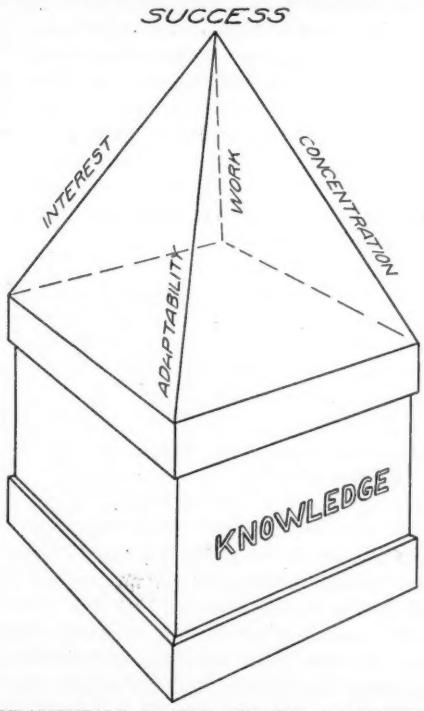
IT WAS "open meeting" night and the hall was crowded with young fellows. For the most part they were firemen, oilers, a few university students —all, perhaps, aspiring chief engineers. The "Chief," of course, was slated for a talk. After his usual preliminaries, he began:

"Boys, I always consider it a pleasure to address young men, especially those young fellows who are progressive and seem anxious to forge ahead. I haven't much time for the man who is satisfied to let the world just drift along without any effort on his part. That particular fellow will, sooner or later, find himself in the discard without having accomplished anything to his credit.

"This is the age of progress and opportunity in the engineering field. Expansion is always toward the better and larger things, creating, as it were, better jobs

for the men who are qualified to handle them. Competition for these jobs is keen and unless an engineer is willing to start at the first step and carefully prepare for each succeeding step, he will just get so far along because the man who is really competent will edge him off and he will not have climbed very far.

"The first requirement necessary for an engineer is interest. A reciprocating engine, a turbine, a boiler, a generator—these things should have something about them that will fascinate you, hold your attention, make you speculate, wonder and think what really wonderful machines they are, and the marvellous accomplishments that are made possible through their agency. There are a lot of engineers, of course, who never give a thought of this kind to the machinery that they operate.



FUNDAMENTALS OF THE PYRAMID OF SUCCESS

"I happened in a plant the other day. I located the chief engineer sitting in a box car chinning with the shipping clerk. They have a big Corliss engine that is a thing of beauty, but it is headed for the scrap heap because of lack of attention. I was looking the engine over and found the other engineer sitting on the pillow block taking a nap. Now, there was a lot of attraction for me in that plant, but for those two fellows the only object was to keep the flywheel turning over. They were not interested in their work, had no system, and, no doubt, were always looking forward to quitting time and pay day. These two men have reached the peak of their advancement as engineers, and, sooner or later, they will be discharged for incompetency. Steam engineering is now considered as a profession. If your heart and mind does not find contentment in the boiler or engine room and you feel that you would be better satisfied somewhere else, I advise you to go there. I have always thought, too, that any man who works anywhere just for the wages he receives is a mighty poor object to have around.

"Assuming that a man is interested, he should have adaptability. If a man is of a mechanical turn of mind, this point usually develops at once. He may be a little awkward at the beginning, but the rough edges will soon wear away.

"I have a motto hanging over my desk which reads: 'Today is the tomorrow that you worried about yesterday.' It is found quite often that men, eager to get ahead, cannot concentrate their minds on any particular job, or cannot study a subject long enough to complete or master it. If you young men will set a goal that you desire to reach and concentrate your mind on that particular goal, regardless of those little bumps and setbacks that you encounter, you will cross the line in the end.

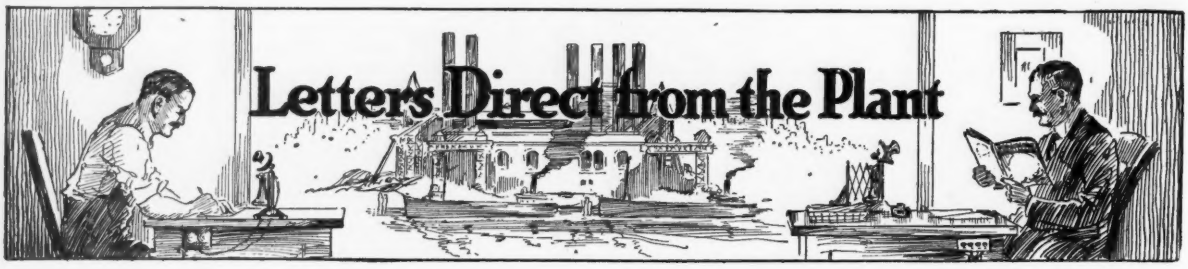
"Suppose that we raise the steam pressure in a boiler to 100 lb. We read the steam gage and it registers so much pressure; we look at the gage glass and it shows us so much water, but no steam. The invisible energy is there stored up ready to do useful work; but unless means are found through, say, the steam engine, no work will be accomplished. Work is usually interpreted as a 12 or 16-hr. grind; a continual digging in to the point of physical exhaustion. In some instances, this definition holds good. The point, however, is that we cannot accomplish anything without work, whether physical or mental. Never let work scare you, for I am unaware of a single instance where the big men of today have not risen by its aid; and, furthermore, no man has ever died from work alone.

"Some of you young men are attending college, taking advantage of the present day opportunities. Others are acquiring knowledge by the longer and harder road. Knowledge, regardless of how you get it, is the very foundation upon which a man builds his success. The man with a trained mind has a greater range of reasoning power, is better fitted to solve his own problems, and to a degree, he can depend upon himself because of his self-reliance. When you boys are graduated you will have excellently trained minds, but you will then have just completed the first step in your apprenticeship. The school room will give you a thorough grounding in the fundamentals of engineering, but remember that you have to get out in the world and come in actual contact with the big and worthwhile things before you can develop."

The chief went to the blackboard and drew a pyramid resting on a base. The base he marked "knowledge"; at one corner he wrote "interest," another "adaptability," another "concentration," and at the fourth corner he wrote "work." At the apex of the pyramid he wrote "success."

THAT FULL ADVANTAGE may be taken of the scientific knowledge already gained or lying latent, Great Britain has established a Department of Science and Industrial Research, which will operate to stimulate the production of the workers, encourage the industries to employ scientific men for the solution of their special problems, and to organize research councils to carry inquiries into industrial and scientific problems of national importance.

EACH OPPORTUNITY grasped makes the next one easier to grasp. Thus is the habit formed.



Automatic Combustion Control

THE WRITER read with interest John Van Brunt's article in the Feb. 15 issue of Power Plant Engineering on the subject of "Combustion Control," because the subject is one that is foremost among the problems of fuel conservation and operating economy today. The writer was, however, disappointed in the extreme, because he had been rather led to believe from the beginning of Mr. Van Brunt's article that he was to be told where the ideal regulator was to be purchased, a regulator that had no time lag due to inertia and the necessary lost motion such as occurs when action is transmitted from different media by mechanisms.

The writer found that Mr. Van Brunt was only criticizing existing regulators, after which he told of what the ideal regulator should do. Then when curiosity was aroused, we were told that "there ain't no such animal" as a perfect combustion regulator.

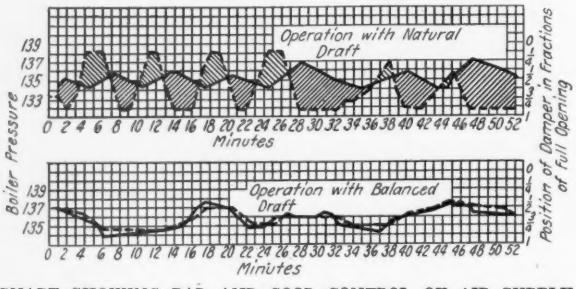


CHART SHOWING BAD AND GOOD CONTROL OF AIR SUPPLY

After reading Mr. Van Brunt's article, one is left with the impression that combustion regulators for combustion control are not a success, although not perhaps a failure; that existing regulators do not function correctly nor fully accomplish the purpose desired of them. The writer wishes to point out that, at best, an automatic regulator or device, can only be expected to accomplish its function somewhat more accurately and more reliably than if that same function were performed by human effort. That many combustion regulators in use today do not give better results is in part due to the fact that they are not properly adjusted to begin with, and in part because they are not properly maintained. Apparently, the idea is too prevalent that all that is necessary is to install automatic equipment, after which operation and efficiency will take care of themselves.

The use of automatic devices, whether for controlling combustion, the operation of hydroelectric plants, or other operation, does not mean that human supervision, inspection and adjustment should be dispensed with. Their use means that, if properly adjusted and properly maintained, these automatic devices will do better than human control would do. This fact cannot be emphasized too strongly in connection with automatic boiler-room equipment and boiler-room instruments.

Few ideals are attainable in this materialistic world, and perhaps nowhere is it more difficult to live up to or even hold any ideals than in the boiler room. As long as we have to get along with anywhere from 50 to 300 per cent excess air in burning coal, as long as we are content to pass nearly 60 per cent of the total heat produced to the condenser in producing a kilowatt-hour, how can we expect to find the ideal combustion regulator? The writer is much more optimistic, however, than is Mr. Van Brunt. He believes he has found the ideal combustion regulator.

Mr. Van Brunt tells us what the ideal regulator should do, and concludes with this statement, apropos the ideal regulator: "At no time will there be more air than required for the load existing at the time, nor will there be less. The curves of rates of steam flow, coal feed and air pressure will parallel each other." The writer believes that Mr. Van Brunt has not done justice to at least one combustion regulator, and shows herewith a diagram to substantiate this belief.

This diagram shows the correlation of steam and air. It is self-explanatory and shows that the regulator accomplishes exactly what Mr. Van Brunt says the ideal regulator should accomplish. The line on the lower diagram indicating air pressure (air flow if you prefer) is seen to coincide with the line showing steam flow or pressure, the two lines being in juxtaposition a large portion of the time during which the data was obtained, namely 52 min. This diagram shows very close control of combustion, and, therefore, practically constant combustion efficiency. If the air line were changed to represent CO_2, the discrepancy would be small, being drawn, of course, to a different scale. The regulator from which the accompanying data was obtained, produces what is known as "balanced draft."

The accurate control of air to the fuel bed means high combustion efficiency, or high CO_2, since CO_2 is the one single important index of combustion efficiency, provided the regulator is properly adjusted for any definite grade of coal; it means, further, minimum wear and tear on blower and blower engine or motor, since these are not subjected to needless work in the way of oscillating from a damper full open to nearly closed with an air supply changing in synchronism over wide limits.

In conclusion, the writer wishes to point out that there is no doubt in his mind but that automatic combustion control will give far higher and more uniform combustion efficiencies, and therefore operating economies in many instances than can be obtained when the air

supply is regulated by hand. For one thing, the air supply requires to be changed so often that there is not time to do it, even if the boiler-room force were willing. Second; the coal supply, the water supply, clinker development, blowing down and other routine matters of a more conspicuous nature will always receive greater attention than will the supply of oxygen, which cannot be seen or heard or smelled. It is for this very reason that first-class recording instruments for recording the flow of steam and air upon the same chart are so valuable; they visualize the correlation of air and steam flow, and thus constitute a constant supervisor of either automatic or human control.

We must at all times remember that boiler-room instruments and automatic equipment are installed, primarily, to bring about better results than can be obtained by human control and a given supervision. These apparatus are not installed to do away with supervision entirely, although they will almost invariably enable fewer men to obtain better results.

K. RANKIN.

I HAVE read with interest in one of your recent publications an article on the subject of combustion control which deals generally with the operation of damper regulators and what is required of them As a result, I feel eager to outline some observations I have recently made in various plants throughout the country. With few exceptions, the plants which I have visited were greatly overloaded. In many of these plants the boilers were equipped with stokers, forced draft and had other scientific means with which to conserve fuel, all of which are essential in these economic days.

It has been my further observation, in connection with stoker fired plants which have been under the control of regulators, to find that in connection with the hydraulic type, the forced draft fans have been either "running wild" or throttled down to the bypass speed, resulting in unfavorable and wasteful conditions. On the other hand, I have seen plants in operation, and stoker plants as well, which were under the control of the so-called compensating or graduating regulator, and while in both instances the hydraulic type and the compensating type were performing their function, the difficulty with all these installations was not with the regulators themselves, but with the method used to control the stoker or fan valves.

The one thing, in my opinion, contributing to the unsatisfactory results obtained was the design of the valves on the fan engines; first, because they were larger than necessary; second, so designed as to prevent gradual throttling. In other words, the feed of the valves themselves, through the design of the levers, was altogether too coarse, resulting in their being either wide open or closed through a slight movement of the regulator.

A valve can readily be designed to prevent this condition, and if the valve controlling the fan engine or turbine will be under close control through the proper arrangement of the valve levers, a graduating acting damper regulator will hold the speed of a fan so close as not to over-influence by draft the combustion of the boiler, or to under-influence it through lack of draft, but will correctly proportion the speed of the fan to the draft demands of the boiler.

As I stated above, in nearly every plant that I visited the boilers were overtaxed anywhere from 150 to 200 per cent during my observations. I was interested in one plant in particular where at times a very quick demand was made on the boilers, causing the pressure to fall suddenly. This plant was equipped with stokers and forced draft and the valves on the engine were very coarse fed and under the control of a hydraulic regulator which was insensitive and operated on about 5 lb. change; the result being that when the boiler lost 5 lb. the regulator opened the valve wide, causing a sudden influx of cold air pressure to the fire, which was not in a condition to receive it, resulting in the cooling of the fires, and causing temporarily a greater loss of steam pressure. When the pressure began to catch up with the demand, the maximum air pressure and the speed of the stokers were such that it built up unnecessarily the amount of fire, and when the pressure was finally recovered the fan was almost completely stopped and the stoker slowed to the minimum speed, the boiler accumulating further pressure through latent heat, resulting in a heavy fire bed and an unnecessary waste of fuel. This performance was repeated several times and it should have been obvious to the operator that his plant was unbalanced.

What I want to make clearer is this—while there are various theories with reference to the control of stoker and fan valves, it is advisable when a quick demand for steam is made to prepare the fires to meet the load through the use of a sensitive graduating regulator and a well controlled valve.

I am convinced that with the proper valve on the stoker engine, operated through a sensitive or compensating type damper regulator, that not only a greater economy will be effected in fuel, but a huge saving in the equipment and a great improvement shown in combustion.

Right here is where the human element must do its part. An engineer must study his plant. He must balance it so as to know at all times what his maximum and minimum draft should be, and then adjust the valve to the fan engine proportionately so as not to over-blow his fire and increase unnecessarily its intensity, but so to balance it as to keep a uniform condition and make allowances for good and bad fuel and the demands made upon his plant, which only study can accomplish.

In other words, it is much better in time of peace to prepare for war than to meet a war half prepared.

JAYS LARKIN.

Why Torches Sometimes Explode

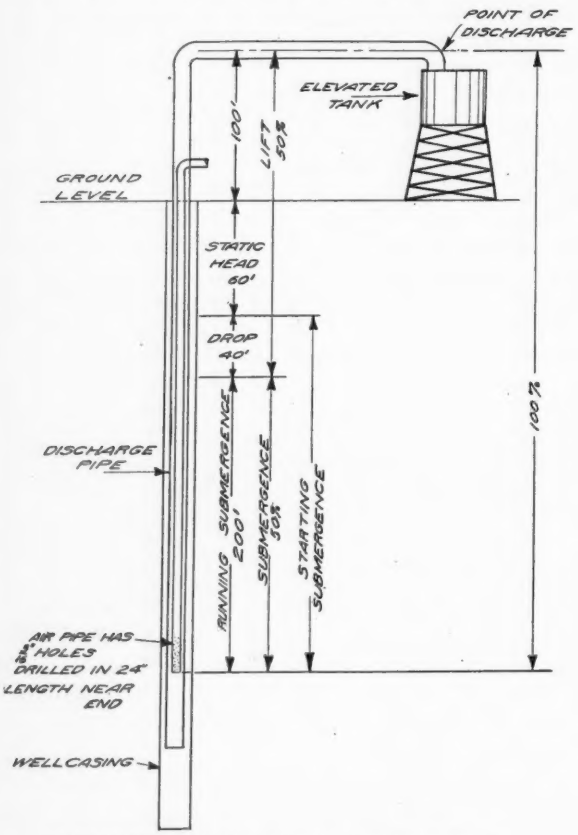
I HAD a little experience with my welding torch that might have proved fatal. I was welding brass, and the torch was hot; the pressure in the acetylene tank was also quite low. Suddenly the tip flashed back and plugged. I reached for a needle to dig out the end of the tip, when I smelled burnt rubber and, feeling the acetylene hose, discovered it was very hot. I immediately shut off the gases at the tanks. After putting the tip in order, the acetylene gas would not flow and I found that the hose was no longer a tube, but vulcanized solid.

I came to the conclusion that when the tip got plugged, the oxygen backed into the acetylene hose and burned there. If the proportion of the mixed gases had been different or more oxygen had backed into the nearly exhausted acetylene tank, I might not be writing this story. It is pretty well known that the acetylene flame will back up into a very hot torch tip. I have actually kept my torch burning in a bucket of water, and any mixture that will burn in water will certainly burn anywhere.

I am not an alarmist. I use my welding outfit every day and feel that it is perfectly safe, unless some abnormal condition exists. CHAS. HAEUSSER.

Principles of the Air Lift Pump

THE WRITER has followed with growing interest the discussion relative to lifting water from a lower level to a higher level by means of air, as started in the



ARRANGEMENTS OF TYPICAL AIR LIFT PUMP

December 15 issue by E. S. R. It would seem from the discussion that the principles underlying the air lift pump are not very generally understood. The writer has had considerable experience in installing the air lift pump and in one case which came to his attention, repairs in the nature of a general cleaning were necessary. This well was constructed about as shown in the accompanying illustration. The bottom of the well required a cleaning out and it was decided at the same time to drill the well somewhat deeper. Accordingly, the discharge and air pipes were removed from the well joint by joint. The well drillers got busy and drilled the well 100 ft. deeper. Upon placing the pipes back in the well, the superintendent of the job made an error in his calculations and got the bottom of the air pipe below the discharge pipe, with the consequence that when the air was turned on the water would surge up in the well casing and run over the ground for a few minutes and then rapidly recede down the casing. The next thing that happened was a spurting of water up the casing wall, caused by the air pressure and low submergence. The water supply to the well was not sufficient to maintain a running submergence; that is, the drop in head was too rapid, otherwise water would have flowed from the casing steadily instead of in spurts. To cure the trouble, the air pipe was withdrawn, the length carefully checked and the pipe re-installed. Several lengths of pipe had to be left out and upon making the proper connections again, the well worked fine.

It will be noticed from the illustration that a discharge pipe is placed within the well casing and that an air pipe is then placed within the discharge pipe. This air pipe can, however, be placed on the outside of the discharge pipe if desired, entering the discharge pipe near its bottom end by means of a fitting, or it may go clear to the bottom of the discharge pipe, and then double back inside for a distance of 10 or 12 ft. with equally good results. The running submergence or the distance from the pumping head to the air inlet should never be less than about 50 per cent of the total distance from the point of discharge to the air inlet. Due to the lag in the supply of water to the well, the water level will drop a certain distance. The distance from the surface of the ground to the idle water level is the static head, and the water level when the pump is working is the pumping head. The difference between these two levels is the drop and is seldom if ever the same in any two wells. The drop must be ascertained in each case by tests. The distance from the running head to the point of discharge is the lift. The required percentage of submergence varies with the lift; comparatively more submergence is required with low lifts than with high lifts. For a lift of about 50 ft., 60 per cent submergence will be required; while for a lift of 300 ft., a submergence of 50 per cent is necessary.

Ingersoll-Rand gives the following formula by Edward A. Rix for calculating the air volume required to raise one gallon of water:

$$Va = \frac{h}{c \log.\frac{H'-34}{34}}$$

In which Va = free air (actual) required to raise one gallon of water.

h = total lift in feet.

H = running submergence in feet.

c = constant as given in the following table.

Lift in feet (h)	Constant (c)
10 to 60 ft.	.338
61 to 200 ft.	.326
201 to 500 ft.	.292
501 to 650 ft.	.257
651 to 750 ft.	.223

The quantity of water that may be obtained from a well per hour depends upon the diameter of the well,

the size of the pipes and the water yielding sands in which the well is located. The actual pumping level of the well, as before stated, depends on the results of tests and the submergence must be based on experience rather than on any given formula. After the pipes are installed the most economical working condition may be arrived at by raising or lowering the pipes in the well until the proper submergence has been obtained.

C. C. HERMAN.

Water Softening in Small Plants

IN REFERENCE to the article by Mr. Vater, I would like to state some of the experience that I have had with a water softener, using lime and soda ash; also operating the same plant under the same conditions without the water softener.

We have a variable water; it runs from 130 grains of hardness down to 4 grains per gallon, and it will make this change in 24 to 36 hr. The change the other way is not quite so rapid, but takes about two weeks. The change from hard to soft is so rapid at times that it is impossible for us to change the treating fast enough. For instance, we are treating for 50 grains of hardness one day and the next day we have a hardness of 5 grains. Then we have a softener full of over treated water. Of course, a small softener would be easily changed, but a large one is not so easily handled.

We have water tube boilers and with treated water we have no scale but we do have serious pitting. We have lost seven boiler drums in the last 5 yr.; we also have excessive foaming when boilers are operated at anywhere near their rating, which calls for a liberal amount of cylinder oil in engines. In order to operate at all we must blow down each boiler any number of times up to 24 in 23 hr. We have tried surface blow-off, boiler skimmers and everything we ever heard of without any relief on the foaming when boilers are fired at their rating.

As I have stated, we have pitting when we treat the water. Now when we stop treating the pitting stops at once; start treating again and the pitting starts again. We have had chemists and feed water experts but none of them have been able to stop the pitting, and the only way they have been able to stop the foaming is by blowing down the boilers.

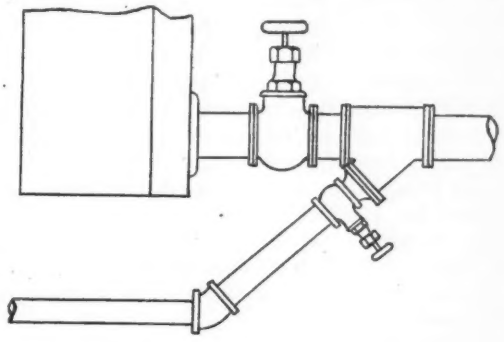
We have an open feed water heater and all water entering the boilers is at 110 deg. F. Our mixing tank has been used about 8 yr. and is as good as the day it was put in, but the steel sides of the softener are pitted about half way through in spots. The plates are gone in large spots under and over the filter bed, and the angle iron is less than one-half as heavy as it was when it was put in 8 yr. ago.

We have lost one high- pressure cylinder head along with piston and rod, due to foaming boilers when using treated water, and have had to replace piston packing rings by the dozen, due to wet steam. We have no foaming with raw water and blow down only 3 times in 24 hr. We have no scale with treated water, but a heavy scale with raw water. The coal consumption is the same for either water due to extra blowing down when using treated water. We use less cylinder oil when using raw water, and rings show practically no wear.

I would like to see in Power Plant Engineering views and experiences of other operating engineers on the water softener and the pitting problem. J. B.

Quick Method of Draining Steam Line

WE HAD scattered throughout our plant a number of reciprocating steam service pumps. These were used off and on during the day as the process work required, but when put in operation quick response was desirable. It was found, however, that several minutes were lost each time the pumps were started up because of the time required to blow the water, which accumulated in the lines, through the blowoff cocks on the pump. In order to eliminate this delay, we rigged up a draining connection ahead of each valve on the pump lines, as shown in sketch. By means of this ¾-in. blowoff connection the line could be cleared of water in a few seconds'



SHOWING HOW BLOWOFF WAS FITTED

time and the pump put in service without delay. It ought to pay to put some such similar drain line on almost any exposed or long steam line where water is apt to accumulate. M. A. SALLER.

Human Engineering

THE EDITORIAL under the title of "Human Engineering," in the Jan. 15 issue, is, to the mind of the writer, one of the best that ever graced the pages of a technical magazine, and is as important to the practical engineer as any treatise that treats with the more direct mechanical problems of the plant. To be a successful engineer, under existing conditions, is an accomplishment of which any individual may be justly proud, and those who strive to gain this distinction realize the importance of putting the best that their personality contains into duties of their profession or trade.

While we may have made the problems of steam engineering our specialty along the lines of a vocation and have adopted this means of supplying our material wants, it is only one phase of existence and when rightly viewed, becomes but a side-line in the game of life; but when we combine this special study with the sane and practical thoughts expressed in that editorial, our views become enlarged, our opportunities increased, and our conception of life beautified.

The mind of man is too great an institution to be confined to any one particular study, and its healthy development depends largely upon its grasp of human

affairs and their relationship to every known problem. "Environment and mental training" become important factors in shaping the course of the individual, but to become useful agents in society, to help create the conditions of our enviroments, and to contribute our share to the mental training of those that help constitute our environments calls forth the personality of each human unit irrespective of the part he plays in the industrial arena. Being engineers does not exempt us from our moral and social responsibilities, nor free us from the duties that citizenship imposes upon us, it is therefore very essential in our pursuit of any special calling to remember that the human side of affairs cannot be successfully omitted from any great undertaking.

Any circumstance that tends to dissatisfaction or mental unrest in or around the plant could perhaps be easily remedied were it not for the fact that those affected carry their real or assumed grievance into their homes and social circle, thereby strengthening the hands of an element whose radical tendencies are fast becoming a menace to the society of the world.

The peculiar position of the engineer in our manufacturing establishments makes him a capable missionary either for good or bad in the welfare of the community, inasmuch as he comes in contact with almost every department of the establishment where he is employed, and the fact that stationary engineers as a body have contributed so little to labor agitation speak well of their ability as individual thinkers. Possessing this quality qualifies them as stabilizers in the great commercial machine.

Much of the unrest that now exists, comes from the fact that men insist upon saying they work for so-and-so when a little sound reasoning will reveal the truth that we are only working for ourselves and those depending upon us. We would not work were it not for the compensation we receive, and the fact that we work with, not for, our employer in the particular business that he may have established does not necessarily imply any inequality in our standard as men. The mill, the mine, the factory and the mart are the great homes of industry where business discipline must be maintained and where its directing heads must scheme and plan for the best interests of all who depend upon its successful operation for their protection, and if every machine in the great power house of industrial progress is expected to perform its particular function day after day, the men in charge must understand the principles of human engineering.

C. H. Stephen.

Did the Engine Run Too Fast?

The above question in the Feb. 1 issue of Power Plant Engineering prompts me to submit the following experience which happened recently with a "fast running" engine, a 14 by 30-in. slide valve engine doing 76 r.p.m.

Previous to my taking over the responsibility of keeping the "thing" moving, the governor pulley (the engine was equipped with a Waters type of spring governor) had been changed from a 4-in. iron pulley with a set screw for securing it to the shaft to a 5-in. wooden pulley.

Let me here explain the construction of this pulley, which was put on under the supervision of the foreman who had it made. It consisted simply of two halves held together on the governor shaft by two long wood screws.

I was on my first week here, but had paid more attention to the governor belt than the pulley, as this was an old style governor and had no safety device in case the belt should break, and the belt had been laced in six different places.

One day shortly after the 1 p.m. whistle blew, I was being occupied with a little firing (this was a one man plant) and noticed nothing wrong until my return to the engine room. Man, O, man! How that old girl was traveling! All she needed was two pairs of wheels and a track!

This was a belt driven outfit and running under. The main belt had little clearance where it ran through a partition to the jack shaft and at every turn the engine made, the belt would strike the partition, which happened to be of brick, and it wasn't cased in either.

I only thank my lucky stars I was around and on my job, not only for my own welfare, but that of all others involved or concerned.

The engine was pounding unmercifully at every stroke and God only knows how fast she was traveling and gathering speed at every turn.

I made one grand and glorious leap for the throttle and shut her down. It did not take long to find the cause of the trouble for the governor pulley was just on the point of dropping off the shaft.

The foreman (?) appeared about this time and after learning what had happened, he procured some sandpaper and together we got it back on and I started up again.

I asked for a new pulley, either sectional or solid, just so long as it had a set screw or two or some other similar device so you could fasten it and feel that it would "stay put" on the governor shaft. All I got back for an answer was: "Oh, that's good enough; just keep an eye on her!" And I did!

Is it any wonder some engineers get to look old and worn when they really are nowhere near that stage of life? The flywheel, which was solid and 10 in. in diameter, was uninsured and now I leave to the readers of Power Plant Engineering what might have happened had somebody not been around just at the right time. It's safe to say it would have been another so-called flywheel explosion or a bad wreck; something would have let go sooner or later.

Now, why will a general manager tolerate such a thing as I have just described when a few dollars would have insured against a similar occurrence? They know and yet they are willing to take the chance, always ready to place the blame, however, and clear themselves when anything does happen.

I soon left this place, being apparently unable to make the "foreman" understand that I needed a new governor belt and pulley along with various other necessities.

I wouldn't shoulder the responsibility of a plant like this and then shoulder the blame later for a serious accident which might easily have been averted with the expenditure of a few dollars. I have been up against other cases where things essential to the safe operation of a plant were needed, but this one had them all beaten.

Leroy Blake.

An Emergency Repair on a Large Nut

THE ILLUSTRATIONS show how we handled an emergency job on a gyratory rock crusher. The shaft with bell on weighs about 5 tons. The square threads on the upper end of the shaft are cut two per inch. The cast-iron nut serves the purpose of raising or lowering the shaft to regulate the fineness of the rock.

The threads in nut A, Fig. 1, stripped, and we had no new one in stock. To wait for a new nut meant a shut-down, so we bored the old nut as shown in Fig. 2. The shaft was raised to the right height, and the nut was placed over the shaft. All unnecessary openings were closed with clay and babbit was poured around the shaft.

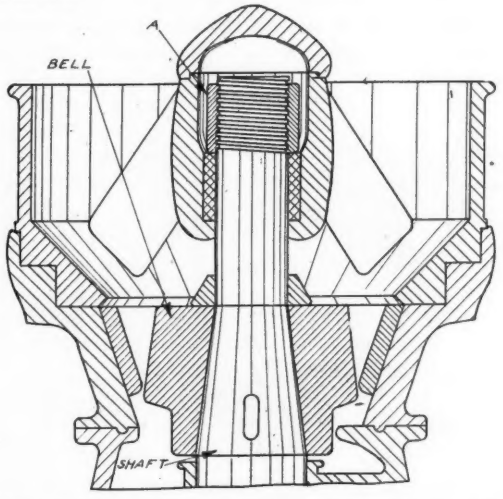


FIG. 1. SECTION THROUGH CRUSHER SHOWING NUT WHICH WAS STRIPPED

After removing the clay and oiling up, the crusher was ready to run in the morning. About two months afterwards, the shaft had to be raised for finer rock, but the babbit had shrunk fast onto the shaft, so with a new steel nut in stock, we drilled two 1¼-in. holes through nut and babbit parallel to shaft, and broke the nut off. The babbit threads were in fine shape.

W. F. JOHNSON.

Over Speed; Heating Compressed Air

ON PAGE 203, Feb. 1 issue, I notice the article by C. W. Spahr, "Did the Engine Run too Fast?" I don't know just what part of the country Mr. Spahr hails from, but the little harmless stick of wood theory is new to me.

In years gone by, we used to leave in the safety pin on Corliss engines, so the governor could not drop on "safety" and shut us down, but we never blocked the governor down with a harmless stick of wood.

Incidentally, during the war, we also took out several hundreds or thousands of extra horsepower, but we never were so near the point of lunacy that we placed the entire plant in jeopardy by interfering with the proper working of the governors.

One engine carrying over three thousand horsepower dropped its entire load. The exciter voltage played tag for a few seconds, then disappeared, and consequently the entire load was lost.

This engine speeded about four turns. Can you imagine the results if the little stick of wood had been in evidence?

It is not engineering when you deliberately disable the governor so that it cannot function properly; it is ignorance or criminal neglect.

When I read of flywheel explosions, and the engineer is killed, I always prefer to think that he was not to blame, that something disarranged the governor; perhaps oil accidentally got on the belt and he couldn't get to the throttle quick enough.

With an engine operating O. K., I have seen oil accidentally spilled on the governor belt and a near accident follow.

A stop operated from the shaft independent of the governor and controlling the throttle is the only solution of safety in a case of this kind.

On page 206, Condenser shows a system of keeping tab on the blowoffs. What do the readers think of recording thermometers attached to the blowoff and registering in the chief's office? Such little pieces of apparatus are not only possible, but in operation. They not only tell the boilers blown, but also the time and length of time of operation.

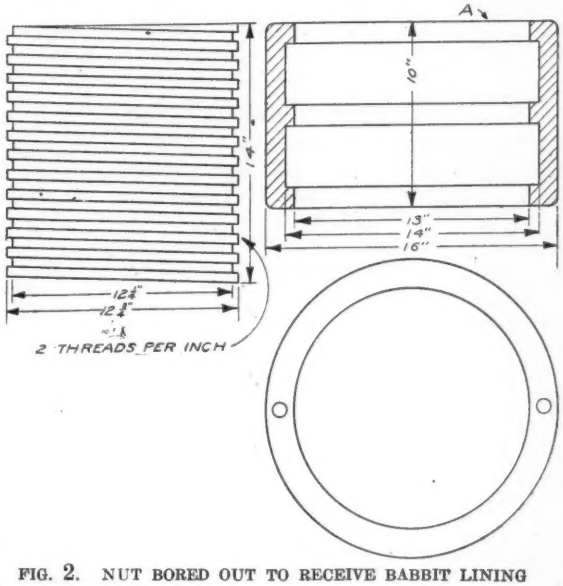


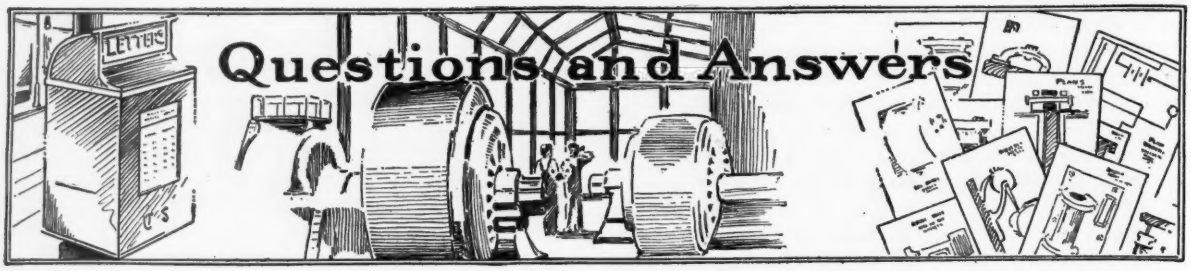
FIG. 2. NUT BORED OUT TO RECEIVE BABBIT LINING

On page 208, W. W. W. asks whether gas will form in a storage tank, under the conditions he mentions. His illustrations indicate that the compressors are 600 ft. away and that he heats the air before entering the reservoir. The oil in the line reaches the re-heater before it gets to the reservoir. What is to prevent the oil flashing if sufficient heat is applied?

If it is possible, I would prefer a cooler at compressors for extracting the water. I believe that a cooler will condense more moisture than any other device and my experience with them has been satisfactory.

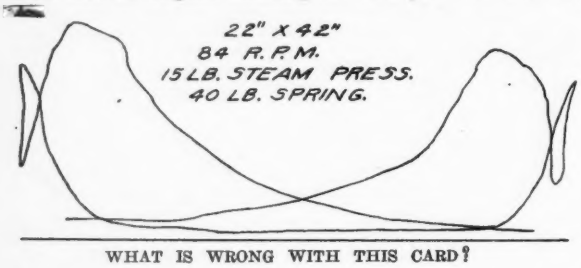
TOM THUMB.

WALL STREET JOURNAL states that rate increases of 30 to 40 per cent predicted on Canadian railroads as result of estimated deficits for current fiscal year would total $28,000,000.



Criticism Wanted

THE CARD shown illustrated was taken from a 22 by 42-in. Brown engine running at 84 r.p.m. on 115 lb.

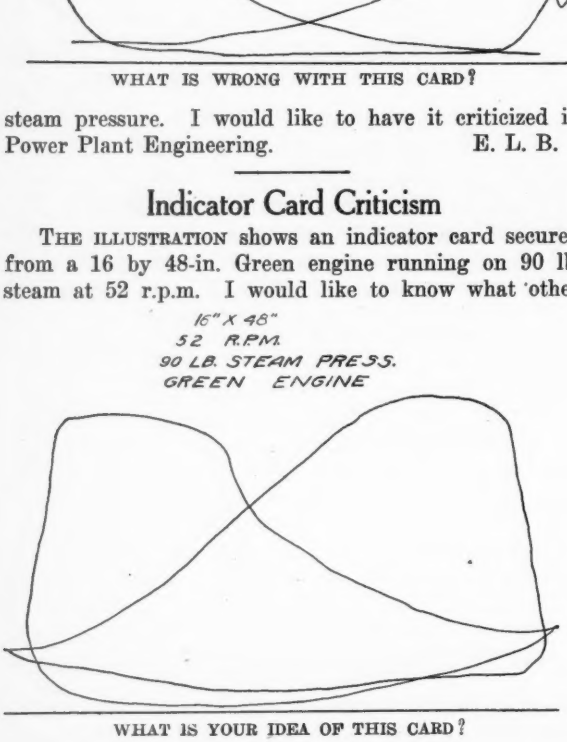


WHAT IS WRONG WITH THIS CARD?

steam pressure. I would like to have it criticized in Power Plant Engineering. E. L. B.

Indicator Card Criticism

THE ILLUSTRATION shows an indicator card secured from a 16 by 48-in. Green engine running on 90 lb. steam at 52 r.p.m. I would like to know what other



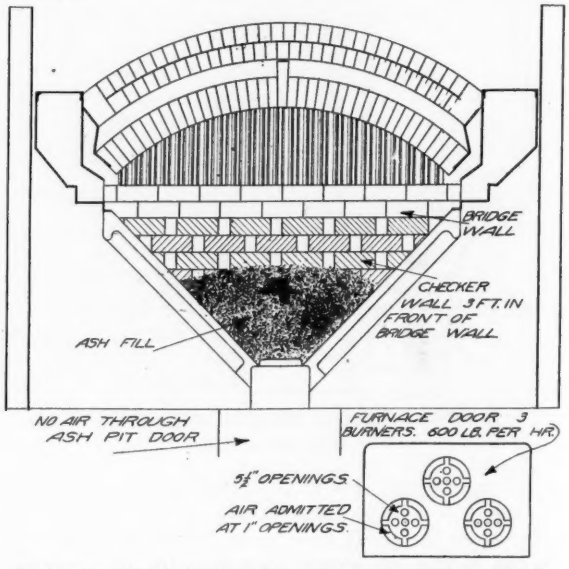
WHAT IS YOUR IDEA OF THIS CARD?

readers of Power Plant Engineering have to say about it. E. B.

Fuel Oil Burning in Vertical Watertube Boilers

THE ILLUSTRATION shows a 360-hp. vertical watertube boiler equipped with a Murphy stoker, which was recently changed from coal to fuel oil. When the change was first made the grates were covered with fire brick and filled with ash up to the furnace door. The flames from the three burners were concentrated on the bridge wall and the heat was so intense at this point that the brick ran like water. The checkered wall was then put in to keep the flame from striking the bridge wall and tubes direct.

My opinion is that this is not the proper baffle, as no air enters the furnace except through the openings at the burners. The heat is radiated to the heating surface and not by convection. Would it not be more efficient to put a baffle or floor in the bottom of the furnace, and have it checkered so as to admit air through the ash pit doors.


BRIDGE WALL
CHECKER WALL 3 FT. IN FRONT OF BRIDGE WALL
ASH FILL
NO AIR THROUGH ASH PIT DOOR
FURNACE DOOR 3 BURNERS. 600 LB. PER HR.
5/8" OPENINGS
AIR ADMITTED AT 1" OPENINGS

SHOWING ARRANGEMENT OF CHECKER-WORK IN BACK OF FURNACE

If there is any reader of Power Plant Engineering who has had experience in a case similar to this, I would like to hear from him. C. J. M.

Refrigeration Questions for Answer

FOLLOWING is a list of refrigeration questions, answers to which by the readers I should like to see published.

1. In mechanical refrigeration, what is the difference between the compression system and the absorption system?
2. What is the difference between the double-pipe ammonia condenser and the atmospheric condenser?
3. How does the stuffing box of an ammonia compressor differ from that of a steam engine? How is it packed?
4. How are ammonia pipe joints usually made up?
5. What is the analyzer and where is it used?
6. What is the difference between direct and indirect expansion systems? Which is the better?
7. How do you know when an ammonia shipping drum is empty?

8. Where would you charge in?

9. What is the difference between a brine tank and a brine cooler?

10. What occurs when your back pressure gage drops to below zero? R. G. S.

Who Will Answer These Questions?

FOLLOWING is a list of electrical questions. Who will answer them for me?

1. For three-phase systems, what are the respective merits of single and combined transformers?

2. What becomes of the energy lost by a transformer?

3. What would be the effect of connecting a direct-current voltmeter across an alternating-current circuit? Why?

4. Which is preferable on an engine driving an alternator operating in parallel with others, a governor sluggish or too sensitive? Why?

5. What frequency is preferable for the operation of alternating-current motors? For lighting? For converters?

6. How is a synchronous converter started?

7. What kind of a motor is best suited for high-speed passenger elevators? For slow-speed freight lifts?

8. Would a plating dynamo give good service on a lighting circuit? Why?

9. Where are synchronous motors used to the best advantage? Where induction motors?

R. G. S.

Massachusetts First-Class License Questions

THE FOLLOWING questions, which I wish you would kindly answer for me, were recently asked an applicant for a first-class license in the state of Massachusetts:

1. What are water-tube boilers?
2. Describe a B. & W. boiler.
3. How many types of condensers are there?
4. How is a surface condenser operated?
5. How is a syphon condenser operated?
6. How high are they?
7. Why is it necessary to make them of such a height?
8. What do they extend from to that height?
9. Could they be operated at a lesser height?
10. If you were operating a noncondensing engine and desired to change to condensing, what would you do about the setting of the valves? Would you change the cutoff?
11. What is the function of the lap on the steam valves of a Corliss engine?
12. If your employer should request you to state the size of boiler necessary to develop 200 hp., how would you tell offhand without stopping to figure out any dimensions?
13. How do you determine the maximum allowable pressure on a Manning boiler?
14. How do you find the size of safety valve for any given size of Manning boiler?
15. If you were carrying 150 lb. pressure and reduced it to 100 lb., what would you do about the safety valve?
16. If you were running a cross compound engine with a jet condenser and the pump stopped, what would prevent flooding of the engine cylinder?
17. When changing from condensing to noncondensing or vice versa, what valve setting, if any, would you alter?
18. How do you set the governor and valves on a Ridgway engine equipped with exhaust steam governor?

M. S. W.

ANSWERS

THE WATER-TUBE boiler is one in which the water is contained in, or passes through, the tubes while the hot gases pass over the outer surface of the tubes transmitting their heat to the water within.

2. A B. & W. boiler consists essentially of a water and steam drum to each end of which a header is connected, passing in a downward direction and between which the water tubes are connected. These water tubes slope downward from the fire box to the lowest point at the blowoff end.

3. In general, there are three types of condensers—surface, jet and barometric.

4. In a surface condenser, the steam is caused to pass over a number of comparatively small tubes, inside of which cold, or comparatively cold, water is passed. This has the effect of condensing the steam and allowing it to fall to the bottom of the condenser, from which point it is removed by means of a condenser pump.

5. The siphon condenser is a modification of the barometric condenser. It consists essentially of a circular conical jet into the largest portion of which the steam from the engine is allowed to pass. The water in passing through the circular orifice exerts a suction on the steam and noncondensible gases with the result that the former is condensed and removed as water while the latter is merely carried out with the water.

6. This type of condenser must be located at a sufficient height to secure a distance of 34 ft. from the level of the hot-well to the center line of the condenser.

7. It is necessary that they be made as high as 34 ft. for the reason that water, if subjected to a perfect vacuum, can be lifted that distance. If they were made at a less height, it can readily be seen that water would be likely to be drawn into the engine cylinder or the turbine casing.

8. This type of condenser is connected by means of a tail pipe to a hot-well.

9. See No. 7.

10. If a noncondensing engine were changed to condensing operation, it would probably be necessary to set the valves so as to cause earlier compression as the back pressure would be extremely low and the engine would be likely to knock.

11. Lap on Corliss valves governs the amount of steam supplied to the cylinder as well as the duration of admission. Were no lap provided, the valve would start to open almost immediately after it had closed.

12. Use the manufacturer's rating of 10 sq. ft. of heating surface per horsepower. On a 200-hp. boiler this would be 2000 sq. ft. of surface.

13. The maximum working pressure on a Manning boiler is that of the largest diameter of its shell and is found by multiplying together the thickness of the plate, the tensile strength of the material and the efficiency

of the joint and dividing this product by the product of the radius and the factor of safety.

14. The area of a safety valve required for any type of boiler is found by means of the following formula:

$$A = 0.2074G \times (W \div P)$$

Where A = area of valve required
G = grate surface in square feet
W = weight of water evaporated per square foot of grate surface per hour and
P = pressure in pounds absolute.

15. Where such radical changes in operation are made as reducing the working pressure from 150 to 100 lb., or vice versa, a new spring should be installed in the safety valve.

16. Modern jet condensers are equipped with vacuum breakers, the object of which is to prevent water reaching the engine. As the water rises in the condenser, due to stoppage of the pump, the float is so arranged that it will open a valve, breaking the vacuum and allowing atmospheric pressure to take effect in the condenser.

17. See No. 10.

18. We do not know what you mean by an exhaust steam governor. The Ridgway engine is supplied with a shaft governor, which operates on a combination of the centrifugal and inertia processes. The valves on these engines are set at the factory and, under ordinary circumstances, the setting should not be interfered with. The cutoff as well as other stages of the stroke are taken care of by this governor.

A Belt Problem

IN REGARD to E. R. B.'s difficulty, page 255, Feb. 15 issue of Power Plant Engineering, I offer the following suggestions: He should see that his generator and engine are both perfectly level and in line, and that the pulley is true, and carries no irregular accumulation of belt dressing.

If this generator has been driven by this engine with another belt with the same load, and no trouble was encountered, and if this belt is put together in the same manner as the old one, then the trouble is caused by the newness of the belt. The belt should be run at about half speed and an occasional application of castor oil should be made to its face to limber it up.

If the trouble has always existed, it may be due to the fact that the belt is too small for the power it has to transmit, and, of course, in that case, after it reached the limit of its transmitting power it would slip off the pulley.

The belt may be defective or out of balance by being heavier in some parts than in others.

E. R. B. fails to state just how much load he is carrying on his generator. The peak load must be given due consideration when figuring the amount of power the belt is required to transmit. A good rule to determine the horsepower a belt of given width will transmit when running at a given speed is, for double-ply leather belts: multiply width of belt in inches by 60, and the product by speed of belt in feet per minute, and divide the product by 33,000; the quotient will be the number of horsepower that the belt will transmit with safety.

The flickering of the lights is an indication of belt slippage. H. W. ROSE.

I NOTE on page 255 of the Feb. 15 issue that E. R. B. is having trouble with the belt on his Allis-Chalmers Corliss engine. This trouble is due to sympathetic vibration. The vibration period of the belt is about the same as the impulses given the flywheel by the piston. Each impulse given by the piston tends to pull the belt and flap it, each successive impulse comes so timed that it makes the flapping and twisting worse. That undoubtedly is the true reason for it.

There are at least two remedies. The engine speed may be slowed down, perhaps about 12 or 14 per cent and the size of the generator pulley decreased so as to give the proper speed. This would put the engine rotation out of harmony with the vibration period of the belt. Perhaps better still would be to shorten the distance between centers to about 23 or 26 ft. This would accomplish the same result. There may be other ways to do the same thing, but the last mentioned seems to me the best. I feel quite sure I have told the real reason for the flapping and also given a correct answer.
VINCENT CHADWICK.

Allowable Turbine Bearings Temperatures

WITH REFERENCE to the above subject as requested by J. H. McK. in Power Plant Engineering of Nov. 15, 1919, and the answer thereto by F. A. Lekava, of Jan. 15, 1920, I do not approve of the idea advanced by F. A. Lekava. The best cylinder oil, generally speaking, contains traces of sulphuric acid and its use is bound to cause trouble.

Since J. H. McK. does not state whether his oiling system is of the force feed or ring oiler type, it is hard to diagnose his case at long distance.

I would insist on the builders of the turbine remedying the evil, which manufacturers are quite ready and willing to undertake, if given the opportunity. If the turbine has been in operation for some time, then it behooves the engineer on the job to get busy and locate his trouble.

If the bearings are of the ring type I would say that he is not using oil of the proper viscosity. (As for using oil that is recommended by the manufacturer, that has no bearing on the case, since it has been my experience to use the specifically recommended oil and get no results.) I have had instances where I was compelled to use one grade of oil in the steam end bearing, and another grade on the exhaust end bearing. Using the same oil in both bearings would result in one running hotter than the other, and when I say hot, I mean hot, for the thermometer registered 220 deg. F. With ring bearings, it is easy to determine whether the proper oil is being used; viz., if the oil foams, leaves a tarry deposit, or emulsifies, it is not right. Dirt, such as lime from waste, unclean conditions of plant, water in oil, compounded oil, leaky packing cases, heat transference, steam chest in close proximity to bearing case, are causes for hot bearings, as well as too close fitting bearings, too loose fitting bearings, vibration, misalinement, racing of turbine, turbine shaft rubbing filler pieces of bearing cases, and where thrust collars are used on tur-

bine shaft, thrusting of turbine rotor, whether it be due to improper design of buckets, nozzles, disc pressure balance holes, or leaky diaphragm packing.

If the turbine bearings are of the force feed lubrication type, then I would look for the trouble in my cooler first. A simple method, if no thermometers are available, is to place one's hands on oil inlet and oil outlet, and note the heat according to sense of feeling. If oil emerges as hot or nearly as hot as it enters the cooling coil, then the coils are dirty, either inside or outside or both.

I have seen instances where hot bearings were caused by this very trouble. It is my practice to hook up cooling coils so that I can bypass the cooling water; in other words, in a counter flow cooler, water enters the bottom of tank, coming in contact first with coils containing coolest oil, and emerges from top of tank where hottest oil coils are. My method is so to hook up cooling water inlet and outlet, that I can cause water to enter either the top or bottom of the tank at will, and by this method I am always able to keep the outside of the coils clean, as I always manipulate the water valves or cocks twice every day. By this method the reversed flow of water will wash out any accumulation of mud, leaves, etc., that may be suspended in the water and drop to the bottom of the tank. In case I have compressed air available, I hook up the water lines, in both instances with air attachment, so that I can produce a swirling motion of water in the cooler, so as to agitate the foreign substances and get them out of tank without having to dissemble the tank.

For dirty, slimy insides of oil tubes, I first use steam to blow out all smudge, etc., then follow with a blowing of compressed air and then wash with hot soda water, stand on end and thoroughly drain, finally blowing out with dry compressed air.

Temperature, as well as quantity of cooling water has a great bearing on the oil temperature of outlet oil. If the temperature of the cooling water is high, it would be advisable to install another cooler, thereby giving greater cooling area. The same holds as regards the temperature of the room.

In conclusion, at best there are numerous things to take into consideration, and it devolves entirely upon the engineer to study his turbine from every angle, to lend an ear to suggestions, but by all means not to try to use every theory advanced. Put them together, shake thoroughly, shake them down again, think some more, then go after the nigger. JAY C. WHEELER.

Preparing a Log Sheet for Ice Plant

IF POSSIBLE, will you send me a sample log sheet for an electrical driven raw-water ice plant? J. A. N.

A. In response to your requests, we do not have sufficient data to enable us to lay out such a sheet for you. We can suggest, however, some of the data which should be included in such a log sheet.

For the ammonia compressor, records should be kept of the time started, time stopped, hours run, kilowatt-hours used and hourly readings of amperes, suction and pressure, temperature of suction and temperature of discharge.

For the air compressor, records should be kept of the time started, time stopped, hours run, kilowatt-hours used and hourly readings of amperes and air pressure. Records should be kept of the time the agitator was started and stopped, the number of hours run and the power consumed.

The general information should include the temperature of air outside and inside as well as hourly barometer readings. The temperature of the raw water and of the brine should be taken hourly and a record of the total amount of ice produced during the day should be kept. Delays should be recorded, noting the length of time and the cause, and space should be allowed for keeping tab on supplies used as well as repairs.

Power for Ice Making

I AM IN CHARGE of a No. 4 Jewel 7 by 8-in. engine operating at a speed of 280 r.p.m. under a steam pressure of 100 lb. Will this engine be able to pull a 12-ton ice machine at full capacity? J. E. F.

A. In order to give you at least an approximate answer to the question embodied in your letter, it has been necessary for us to make an assumption as to the mean effective pressure of the steam within the cylinder of your engine.

You state that the steam pressure, which we presume is that of the boiler, is 100 lb. As a consequence, we have assumed a mean effective pressure of 60 lb. The horsepower of any steam engine may be calculated by means of the following formula:

$$Hp = \frac{Plan}{33{,}000}$$

Where P is the mean effective pressure in pounds per square inch, or 60 in this case; l, the length of stroke in feet, is 8/12, or 0.66 feet; a, the area of the piston, is equal to 0.7854×49, or 38.48; n equals 560 strokes per minute, or

$$Hp = \frac{60 \times 8/12 \times 38.48 \times 560}{33{,}000} = 26.12 \text{ hp.}$$

Roughly speaking, we may estimate that 1½ hp. is required per ton of refrigeration so that for a 12-ton machine you will require $1\frac{1}{2} \times 12$, or 18 hp., thus indicating your engine to be of sufficient capacity to operate the machine referred to.

The Reason for the Lost Motion

IN REGARD to the question I asked, as to the reason for the short stroke of my Fairbanks-Morse boiler feed pump, I will say that I have located the cause of the trouble.

I found that the pump was old and considerably worn. I took up a lot of lost motion, and am having no more trouble. P. W. M.

IT IS ANNOUNCED in the New York Times that the president of the Standard Oil Co. of New Jersey predicts that the great oil problem to be solved is meeting increased demand in the future. He estimates that in 1925 the total needs of the oil industry in the United States will be about 650,000,000 bbl., as compared with 436,000,000 bbl. used last year.

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Size and Efficiency

Development of industries has in the past tended toward concentration into large organizations and large plants. In the minds of some, there has been a question of how far this could go before the disadvantages of lessened loyalty to employers, less appreciation of the individual worker, and less effective supervision would offset the advantages of decreased overhead expense and economy in buying materials and in selling product.

Evidently in some organizations the limit has been reached, for there have been attempts, by dividing into departments and separate plants, conducted independently of each other with respect to manufacturing and selling, and co-ordinated only in financial management, to reproduce the conditions of smaller organizations competing with each other.

From the standpoint of the community, whatever will result in lowest selling cost of product is advantageous. Hence, centralization is to be desired up to that point. Use of labor-saving machinery, expert supervision, buying and selling in quantities to get the best prices on materials and the lowest costs of distribution are to be desired. But, except in the case of industries such as water supply, transportation and telephone systems, where effectiveness is increased by a monopoly of the field, so regulated as to safeguard the interests of the public, a point is soon reached beyond which the advantages of size are overbalanced by the disadvantages, even considering the interests of owners alone. And the temptation to abuse of great power, and removal of the restraints of competition are a distinct loss to the public interest.

In addition, the concentration of business in the hands of giant corporations works toward the piling up of big populations in industrial centers, depleting the smaller cities and rural districts with resulting conditions that are unsatisfactory and injurious to workers, employers and the country at large.

In the case of power generation, there is a like tendency to concentration, and a like limitation. It is necessary for a plant to have capacity to care for the maximum demands of customers. If the load is all of like requirements, this is likely to result in a low load factor, which could be improved by throwing together stations of diverse requirements. But simply piling together station loads of like requirements will not greatly reduce cost of generation after the size of single units has reached about the maximum of efficiency, which analysis has shown to come at around 5000 kw. Some gain will be secured in generation, but it is likely to be offset by costs of transmission, transformation and loss of efficiency when running the big units at light loads.

By employing the best brains in supervision, it is possible to secure the best planning for equipment and operation, but this can be achieved by co-operative action of a number of medium sized plants as effectively as by combining plants and using larger units. And by a system of interconnection, and emergency interchange of current, greater reliability can be secured than with a smaller number of units of increased size.

As in any complex problem, the best solution in any given case must be attained by careful consideration of

the circumstances of that case. General rules are useless and misleading. But study of the present continuing tendency toward overgrown concentration, especially in manufacturing organizations, leads to the belief that in many cases we have passed beyond the economic limit and have acquired, as a by-product, great difficulties in maintaining satisfactory relations between employers and workers, desirable living conditions, and rational balance between manufacturing and agricultural activities of the country.

Milwaukee Pulverizing Coal Installation

For about two years, the Milwaukee Electric Railway & Light Co. has been experimenting with and developing an installation of pulverized coal burning equipment at its Oneida Street station. Originally but one boiler was equipped with powdered-coal burners; today five boilers use this form of fuel. The actual facts concerning the installation have been kept quiet, and inspection of the plant has not been granted to visitors, on the ground that the company was not ready to publish its findings as to pulverized coal.

But, on February 19, a meeting was held at Milwaukee, under the auspices of the Employes' Mutual Benefit Association Technical League, at which John Anderson, chief engineer of power plants, Milwaukee Electrical Railway & Light Co., presented a paper on the subject of "Pulverized Coal." The presentation of this paper was the first authentic information given out concerning the results obtained with the pulverized coal installation under actual operating conditions extending over a considerable period of time. The matter was adjudged of such importance, that invitations were distributed to a very large number of consulting and operating engineers, the engineering societies and the technical press. The result was that the meeting in Milwaukee on February 19 was attended by about 500 engineers from many cities. After the presentation of Mr. Anderson's paper, an inspection trip to the Oneida Street station was made, the first inspection allowed.

After having enumerated the advantages of pulverized coal in general, Mr. Anderson took up the question of when the use of pulverized coal would be found advantageous and when it was not feasible. He stated that pulverized coal installations are not feasible in every location, nor when the size of the plant is less than 2500 developed boiler horsepower, on a 24-hr. operating basis. The experiences in Milwaukee have been pleasing, and pulverized coal is proving successful. The men prefer powdered coal burning to handling stokers; it is being found economical; appears to lessen the formation of scale inside the boiler tubes as compared to stoker firing; eliminates entirely all trouble due to smoke and soot since smoke is absent. The corrosive effects of sulphur in coal are lacking because of the extraction of all but 1 to 2 per cent of the moisture in the coal before burning. No trouble nor any explosions have been experienced and operation has been flexible, reliable and efficient.

The results at Oneida Street have been so satisfactory that the Milwaukee Electric Railway & Light Co. have decided to construct another station for burning pulverized coal exclusively. This station, the ground for which is already broken, will be know as the Lake Side station, will contain, initially, eight 1306-hp. boilers, and will be built long and low to facilitate coal handling and minimize the lift. The design has been termed the "bungalow type" by the engineers of T. M. E. R. & L. Co. because of the comparatively low height and large area covered. It is expected to have this station in service before the winter peak takes place.

From November 11 to 15, 1919, the five 468-hp. boilers at Oneida Street were given a very complete test under actual operating conditions, which was dwelt upon by Mr. Anderson. This test is probably one of the most extensive ever carried out, since the test was virtually a test of the entire pulverized coal section of the station. In other pages of this issue will be found a description of the salient features of the pulverized coal installation at Oneida Street, and results of the above-mentioned tests.

Helps to Make the Plant Safe

Power Plant Engineering is pleased to announce an arrangement with the National Safety Council whereby that organization will furnish a series of special safety articles for Power Plant Engineering, starting in the issue of April 1, 1920.

This arrangement makes available to the readers of Power Plant Engineering in large measure the valuable services of the National Safety Council—the nation's clearing house for information on statistics, methods, and experiences in accident prevention, sanitation and health. Inasmuch as the National Safety Council is a non-commercial co-operative association of some 4000 of the country's largest industrial concerns, governmental agencies, technical schools, etc., membership includes the great bulk of the safety engineering knowledge and talent of the United States.

During the next months, Power Plant Engineering will publish articles prepared by the National Safety Council on such subjects as: Boiler rooms; cranes; belt shifters and belt shippers; belts and belt guards; shafting, couplings, pulleys, gearing; engine guarding and engine stops; oiling devices and oilers; exits, fire alarms and fire drills; accident records; gas and electric welding; fire extinguishment; manila and wire rope; fire causes and prevention—common hazards; electrical equipment in industrial plants; first aid and industrial hospitals; private fire brigades; fuel handling and storage; ventilation; conveyors (chain, belt, bucket, also gravity chutes); and compressed air machinery.

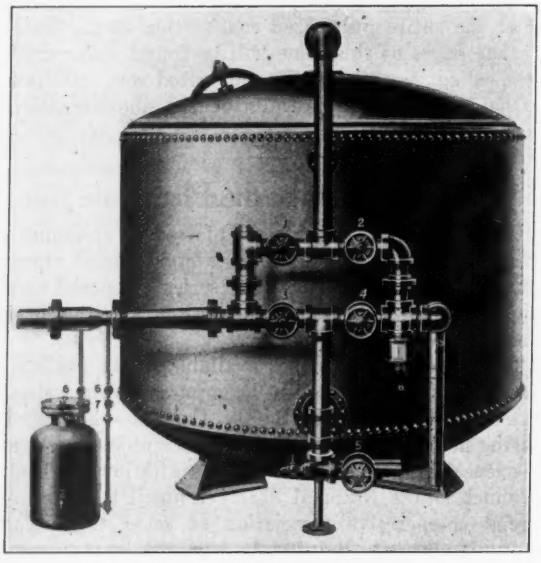
THE ONLY thing that lasts, that does not lose its flavor and grow stale, is anticipation. An event is soon over. At the end of the feast is the stupor. A pungent smoke grows flat in the smoking. Ambition is applied anticipation.

ACCORDING to information from San Francisco, the Standard Oil Co. of California has been compelled to limit exports of refined oil to a minimum, because of shortage of oil. It is stated that crude oil production in California is 25,000 bbl. a day short of requirements, and a deficiency of 10,000,000 bbl. is indicated for this year.

A New Rapid Pressure Filter

SHOWN in the accompanying illustration is a recently developed rapid pressure filter made in capacities of from 2000 to 216,000 gal. each 24 hr. Essentially this filter consists of a closed cylindrical shell of iron or steel containing a layer of carefully selected silica sand superimposed on gravel graded so that its voids are smaller than the sand grains.

On the style of filter shown a specially designed manifold strainer system is provided, embedded in cement mortar over a concrete or stone filling. Brass



NEW RAPID PRESSURE FILTER

strainers are used and these are well secured and distributed over the area of the filter, at the same time offering little resistance to the passage of water in its direct or reverse flow. During back wash operation, they serve to distribute the water evenly over the sand bed.

Only gate valves are used and the wrought or cast-iron piping together with the containers are protected by a coat of non-corrosive paint.

Coagulant tanks are provided for the feeding of alum to the untreated water as is also a Venturi tube on this style, which automatically varies the flow of chemical in proportion to the flow of raw water.

In normal operation of this filter, valves 1 and 5 are opened, which allows water to enter at the top of the filter and pass on downward through the sand and gravel to the outlet. Valve 7 on the coagulant tank is set to feed sufficient chemical to produce clear filtered water. During backward operation the water flows through the filter in exactly the opposite direction entering through valve 3 and passing out through the top opening of the container through valve 2 to the drain. By opening valve 4 the first filtered water is wasted and as soon as the water appears perfectly clear in the sight glass it is shut. Valves 6 shut off the coagulant flow.

ENGINEERING advance is responsible for the world's progress, yet the engineering profession enjoys less prestige than that of the merchant or banker.

Innovation in Storage Heater Construction

THE new storage heater shown herewith and recently placed on the market is intended to supply hot water in hotels, apartment houses, factories, etc. It departs from the general practice as regards the construction of the heating surface. It has been standard practice with manufacturers to use U tubes for the heating element of a storage heater. Careful study and experimentation have shown that practically all of the work of heating is done in the upper or outgoing portion of the U tube and that the lower, or return portion of the tube simply acts as a drain pipe and returns the condensed steam to the steam head. It is therefore obvious that in a U tube heater practically half of the tubing is useless as a heating medium. Furthermore, a certain volume of exhaust or live steam, when condensed, will occupy only about 1/1600 of the volume of the steam. Therefore the large area of the drain tubes in a U tube type of heater is absolutely unnecessary and waste material.

The storage heater shown is designed with a certain number of straight tubes in the steam element, and these tubes are of sufficient length to insure that the required heating will be taken care of and that all of the steam will also be condensed when it reaches the rear end of these heating tubes. It is therefore only necessary to provide an area of drain tube section sufficient to carry the condensation back to the steam head.

The heating surface consists of seamless drawn brass tubes expanded into a fixed tube plate at one end, and a floating tube plate at the other end, thus permitting expansion and contraction of tubes without strain on the tube joints. This construction, as contrasted with the U tube, eliminates the necessity for removal and scrapping of a large portion of the tube surface in order to replace an inner tube—as is the case in U tube construction. The tubes are all of the same length and this

GENERAL VIEW OF NEW STORAGE HEATER

reduces the spares necessary to be carried in stock, and in fact permits the purchase of stock tubing to replace worn-out tubes.

The shell is regularly furnished of welded construction, but can be riveted if preferred. A manhole is provided to permit easy access to the shell for inspection and cleaning.

ACCORDING to statistics made public by F. W. Dodge Co., New York, contracts awarded for building and engineering operations in January in 12 states north of the Ohio River and east of the Missouri River reached record total of $235,848,000, more than twice the value of contracts awarded during any January in the last 10 yr.

Book Reviews

CONTROLLERS FOR ELECTRIC MOTORS, by H. D. James; 354 pages, 259 illustrations; New York, 1919; price, $3.

Ever-increasing application of electric motors to the industries with their varied and exacting service requirements has resulted in the development of innumerable forms and types of controllers and controlling devices. Many of these are extremely simple in construction and operation; others, however, are complicated to a high degree and require for their continuous and satisfactory working and proper maintenance an intimate knowledge of their principle of operation and details of their construction. Manufacturers' literature and instruction pamphlets as a rule provide the man in charge of such electrical equipment all the information he may desire or at some critical time require. Such information is, however, not always available when needed and frequently does not apply to the particular type, form or size of device in question, leaving the man stranded or forced to solve his problem as best he may.

In order therefore to meet the requirements of men charged with the installation, operation and care of electric motor controlling devices, the author has compiled in this volume the series of his articles on this subject originally published in the Electric Journal during 1917 and 1918 with some added text and illustrations. Not only are the various types of controllers, their principle of operation and details of design very thoroughly discussed, but line drawings showing the scheme of connections to be employed are illustrated, although the diagrams given are more for general information than for use in actual construction work. For such purpose the author suggests obtaining the necessary diagrams and instructions from the makers.

In addition to the more elementary phases of the subject there are treated the following: Direct-current and alternating-current controllers; resistors, protective devices; series-parallel control and the electro-pneumatic contactor; voltage control for direct-current motor; mine hoists, machine tool controllers and controllers requiring low initial speed, such as printing presses and rubber calenders; and steel mill controllers. The seven closing chapters are devoted to cranes, car dumpers, ore and coal bridges, coke, elevators, electrical equipment for oil wells and locomotives for mines and general industrial purposes.

A review of the book reveals the broad and important field covered and its value to the electrical workman who has ought to do with apparatus for the control of electric motors.

THE METRIC FALLACY, by Frederick A. Halsey, 229 pages, 6 by 9 in. Second edition, 1919, New York; price, $3.

In the preparation of this book, Mr. Halsey. who is commissioner of the American Institute of Weights and Measures, made an investigation of the claims made for the metric system and especially of the claim that its adoption as the standard for the United States is necessary in the interest of export trade. The book is a summary of this investigation and in view of proposed legislation to make the metric system compulsory, it is performing a valuable service to the country in presenting facts from which conclusions can be drawn.

The author holds that the argument for the adoption of the system is based on the assumption that it is a simple matter for a country to change its weights and measures, whereas years of experiment and experience have demonstrated that this change is of such difficulty that in no country is it complete, while in most of them it is a grotesque failure. Another fallacy pointed out is the assumption that with the adoption of the metric system, or rather its introduction, the old units will disappear. Mr. Halsey's studies convince him that this is not the case, that in no country has there been brought about a uniform system in domestic affairs. Instead of doing away with confusion, therefore, it has brought more confusion; instead of a saving of time in calculations, the continued use of the old system involves the addition of calculations for conversions between the old and the new; while the argument for fewer and simpler ratios between units disappears when it is considered that a dual system introduces far more and far worse ratios between old and new units than those which now obtain.

Each chapter deals with a particular phase of the question, presenting facts and arguments that cannot be refuted, and proving that the choice of the American people is between uniformity based on the English system and confusion caused by the mixture of the metric units which metric legislation can force into use and the English units which the people cannot and will not abandon.

The arguments are presented by Mr. Halsey under the following heads: The Metric System in France; The Metric System in Latin America; The Metric System in Export Trade; Confirmation of These Findings; All Metric Arguments Destroyed; The Metric System in Great Britain; Is the Metric System Better Than Others?; "Simplifying" Our Weights and Measures; The Metric System in Every-Day Life; The Metric System in Primary Education; Learning the Metric System; The Metric System in Manufacturing; The Metric System in Engineering; The Metric System and the Scientist; The Metric Equivalent Scheme; The Metric System and the Saving of Time in Calculations; The Metric System and the English Language; Our English Weights and Measures; The Decimalization of Weights and Measures; Specimen Flights of the Metric Imagination; The Story of the Berry Baskets; The "Metric" Carat; The World Trade Club; The Metric System and the Valve World; A Rational Weights and Measures Program.

COMPLETE PRACTICAL MACHINIST, by Joshua Rose; cloth, 547 pages, 432 illustrations; twentieth edition; New York, 1920; price, $3.

In this, the twentieth edition of this practical book, several new chapters on machine tools have been included. Various commercial types of machines and some of their outstanding constructional features are well illustrated and described.

The book starts out, like the older editions, with a description of the various types of lathe and planer tools and their uses. Chapters are devoted to lathe accessories, such as dogs, chucks, etc., to hand turning, and to tool forging and grinding. The subject of drills, taps and dies and other hand tools is well covered. The

chapter on vise-work contains some good information. Interspersed throughout the book are a number of practical examples and descriptions of methods of doing various kinds of work, such as turning an eccentric, or a piston ring, and fitting connecting rods, cylinders, etc. The second portion of the book consists of the machine tool descriptions mentioned above, and the book concludes with a chapter on setting slide valves of simple steam engines and a brief description of the piston pump.

This book should appeal to the young machinist or the power plant man who desires practical information on this subject.

HENDRICKS' COMMERCIAL REGISTER OF THE UNITED STATES FOR BUYERS AND SELLERS, 2703 pages, cloth. Twenty-Eighth Annual Edition, 1919-1920, New York; price, $12.50.

The useful work, which has just been published, after being delayed for two months, contains several improvements. The most noticeable is the new method of exterior indexing by coloring the front edge red, white and blue to indicate the different main sections of the book.

First is blue, on which is stamped the words "Trades Index." This is a section of 162 pages, in which every product listed in the book is indexed and cross-indexed for ready reference. The red section is the main classified trades list. It contains 1813 pages, listing over 18,000 different products. In the present edition we find over 1,200 new headings, including many headings completely covering the chemical industry. The third section of the book, as indicated by the white edges, contains 216 pages, listing the trade names under which products are manufactured, with the name and address of the manufacturer. The second blue section is the alphabetical section of 487 pages, containing all the names in the book in one alphabetical list with addresses, and their main line of business. This is followed by the index to advertisers, of 20 pages, containing a full list of branch and foreign offices following each name.

It is an excellent work, a copy of which should be in every sales and purchasing department. For the former, it contains complete lists of all prospective customers, and, for the latter, it shows at a glance the producers of any product which may be required. The list of trade headings covers from the raw material to the finished article all products connected with the electrical, engineering, hardware, iron, mechanical, mill, mining, quarrying, chemical, railroad, steel, architectural, contracting and kindred industries, and the firms listed cover producers, manufacturers, dealers and consumers.

News Notes

CALVERT TOWNLEY, Assistant to President of the Westinghouse Electric & Manufacturing Co., was re-elected Vice-President of the United Engineering Society for the year ending January, 1921.

Upon graduation from Yale, Mr. Townley became connected with the Westinghouse Co., serving with the organization 17 yr. successively at Cincinnati, Pittsburgh, Boston and New York. At the end of this period, 1904, he resigned and for 7 yr. was engaged in executive railway work.

After renewing his connections with the Westinghouse Co., in 1911, he became Assistant to President, supervising many of the company's indirectly related activities. He resides in New York City and is a member of the Engineers, Yale, Automobile, Scardale, Railroad and Bankers Clubs.

C. M. VILEY, for many years interested in the Perolin Co. of America, has recently sold his holdings in that company and incorporated the firm of C. M. Viley & Co., investment bankers, with general offices in the Boatmen's Bank Bldg., St. Louis, Mo. His many friends in the power plant field wish him success in his new enterprise.

CYRUS THURSTON JOHNSTON, mechanical and electrical engineer, eldest son of Clarence H. Johnston, architect, died at his home in St. Paul, Wednesday, Feb. 25, after a brief illness. Mr. Johnston was a graduate of the Massachusetts Institute of Technology, class of 1909, and at the time of his death had entire charge of the heating, plumbing and ventilating work in his father's office. His career was one of brilliant promise and his untimely passing is lamented by a host of friends.

Trade News

THE ANNUAL CONVENTION of the Keystone Lubricating Co. was held Jan. 14 to 17 and attended by the district sales managers, district office managers and salesmen. During the convention, addresses and talks were given on The History of the Company, by H. A. Buzby, vice president; on Credit Relations, by W. F. Buzby, the treasurer; a series of open discussions on service, sales, and consumers' technical problems, by members of the organization; on Our Foreign Relations, by N. T. Buzby, secretary of the company; on Results and Rewards, by D. S. Paterson, marine manager; and on Lubricants and Their Application, by T. O. Organ, consulting engineer. The concluding address was made by A. C. Buzby, president and founder of the company, who was presented with a beautiful testimonial from the members of the organization.

IN ORDER to look after its rapidly growing business in California, Arizona, Nevada and the state of Sonora, Mexico, the Jeffrey Manufacturing Co. has opened a new branch office in Los Angeles, Calif. This office will be in charge of F. R. Field, who has been manager of the Denver office. Mr. Field is well known in this territory, and his many years of successful salesmanship and a thorough personal knowledge of the west and the requirements of its buyers, especially fit him to take care of the constantly increasing demand for Jeffrey products in his vicinity, and render valuable assistance to clients in solving their elevating, conveying, crushing and mining machinery problems.

THE BOILER-KOTE method of removing scale and preventing its re-formation in boilers is described in an illustrated booklet from The Boiler-Kote Co., 343 S. Dearborn St., Chicago.

BULLETIN No. 1120, relating to the Stratton Jr. oil separator, was lately received from The Griscom-Russell Co., 90 West St., New York.